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aHD1401.J68

The Journal of

Agricultural Economics Research

Vol. 45, No. 3, Fall 1994

United States Department of Agriculture

Economic Research Service

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Contents

In This Issue

The papers in this issue graphically illustrate the wide range and diversity of research activities undertaken at the Economic Research Service. While ERS continues the painful task of downsizing, the research agenda is as relevant and timely as ever. The authors in this issue address topics on food stamp program participation, commodity price variability, farm real estate equity investments, meat demand, and the meat packing industry. There is something for everyone in this issue.

In our lead article, Bill Levedahl reports that approximately one-half of eligible nonparticipant or "outreach" households for the Food Stamp Program did not think they were eligible. Past studies implied that programs designed to inform households of their eligibility be directed at groups with the greatest number of outreach households. His paper illustrates that the economically efficient use of informational outreach expenditures may require concentrating outreach efforts on groups of households with fewer but more responsive uninformed nonparticipants. The results show that even though there are a greater number of outreach households headed by a single individual, economic efficiency suggests that households headed by a married couple be contacted more frequently since they are more responsive to informational outreach. This conclusion is in contrast to previous recommendations that households headed by a single individual should be contacted more often.

Richard Heifner and Randal Kinoshita argue that differences among commodities in price variability and longterm price trends are important for understanding the fundamental changes underway in agriculture. This knowledge is important input for private decisions about investments in farming and for public decisions about farm programs. The authors show that agricultural commodities exhibit important and persistent differences in price variability, which suggests that variability depends largely on inherent commodity characteristics, such as the elasticity of supply, production lags, yield variability, foreign production variability, storability, and elasticity of demand. They also find that government policies and programs and other institutions appear to have moderated price variability in some cases.

In our third article, Bill Hahn tackles the difficult issue of the stability of U.S. consumer demand for meat. He shows that econometric models imply that demand is fundamentally unstable while indicating that a good way to build taste instability into econometric demand equations is to specify them as random coefficient models. He proceeds to estimate a random coefficient model of meat demand and finds significant evidence that taste instability has caused fluctuations in the elasticities of demand for beef, pork, chicken, and turkey. His results also show that the general trends in consumer tastes have tended to favor poultry demand over beef demand. Pork demand appears to be relatively stable. The estimates support the views of those who believe that shifts in consumer tastes have hurt the demand for beef relative to the demand for poultry.

Mark Johnson, Ron Mittelhammer, and Don Blayney examine the reaction of stock prices in the meat packing industry to changes in federal regulations and farm programs. Their research builds upon the results of previous studies in determining conditions under which different types of regulations will impact the wealth of shareholders. Three general conclusions are supported by this study: 1) regulatory actions, such as safety and inspection programs, that increase processing costs can actually increase shareholder wealth if increases in demand due to increases in quality are expected to outweigh the impact of increased costs; 2) regulations affecting costs of slaughter can significantly impact the industry, and; 3) market participants are adept at analyzing the net impacts of regulations.

In our last article, Charles Dodson studies farm real equity investments. Historically, farm businesses have raised capital from owner equity, debt financing, or leasing. Nonfarm businesses, on the other hand, can raise capital through various other financial instruments such as stock, limited partnerships, real estate investment trusts (REIT's), and leases. Production agriculture's unique structural characteristics have restricted the use of these capital sources. These restrictions have impacts on the growth, liquidity, inter-generational transfers, and risk-return tradeoffs of farm businesses. This paper examines the potential market for external equity investments in farm businesses. The potential for investment by nonfarm investors in U.S. farm equity is estimated by applying a micro-model of the nonfarm equity market to USDA's Farm Costs and Returns Survey. The analysis indicates a potential market from farm operators of approximately $9 billion. REIT's are discussed as a possible institution to unite farmers and investors. Finally, Dodson finds the longterm

downward drift in real farm prices, while reflecting major gains to consumers, is grounds for continuing concern for persons and firms in agriculture.

Our book reviewers give high marks to four new books that cover a diverse spectrum of issues ranging from commodity advertising and informational approaches to regulation to dairy policy and the economics of global climate change. These new topical books are written for a variety of audiences that include applied economists, industry analysts, regulators and policy decisionmakers.

LeRoy Hansen calls attention to *Economic Issues in Global Climate Change: Agriculture, Forestry, and Natural Resources,* edited by John Reilly and Margot Anderson, as one of the few sources of economic analysis of this emerging issue. He recommends the book to research economists interested in modeling the impacts of global climate change rather than policymakers, given the rather technical presentation of most chapters. However, he notes that policymakers could gain insight from some of the less technical material.

Larry Salathe recommends *Political Economic Analysis of U.S. Dairy Policies and European Community Dairy Policy Comparisons* by Mary Marchant as a good reference on models of the dairy industry and models that endogenize government behavior. He notes that the book also contains a good history of U.S. and EC dairy programs up through the mid 1980's but lacks much discussion on the radical changes that have taken place in U.S. dairy programs since that period.

Jean Buzby praises the new book by Wesley Magat and Kip Viscusi titled *Informational Approaches to Regulation* for providing a synthesis of existing literature on informational regulation and making contributions to the design and evaluation of such regulations. She recommends the book to those working in the area and to those curious about consumers' reactions to risk.

Karen Ackerman says that *Commodity Advertising: The Economics and Measurement of Generic Programs* written by Olan Forker and Ronald Ward is the first comprehensive study of generic advertising and commodity promotion programs. She gives the book high marks for its clarity of presentation, readability, and coverage of issues. She notes that the book is geared toward domestic programs and issues and does not recommend it for those looking for specifics on the array of export and trade enhancement programs. The authors build upon their own vast research experience in this area to provide insight, guidance, and perspective to this important topic.

James Blaylock
David Smallwood

Maximizing the Expected Food Stamp Program Participation from Informational Outreach Programs

J. William Levedahl

Abstract. *GAO (1988) reports that approximately one-half of the eligible nonparticipants did not think they were eligible for the Food Stamp Program (FSP). These nonparticipants are denoted as "outreach households." Past studies (GAO, 1990; Coe) imply that programs designed to inform households of their eligibility (informational outreach programs) be directed at groups with the greatest number of outreach households. This paper illustrates that the economically efficient use of informational outreach expenditures may require concentrating outreach efforts on groups of households with fewer but more responsive uninformed nonparticipants.*

Keywords. *Food Stamp Program, outreach, eligible nonparticipants*

Like other low-income assistance programs, not all households eligible for the Food Stamp Program (FSP) participate.[1,2] The most recent investigations into nonparticipation in the FSP have been conducted by the GAO (1988, 1990). These investigations used data from the 1979 and 1986 Panel Survey of Income Dynamics (PSID). They report that approximately one-half of the nonparticipating households who were eligible for the FSP were unaware of it. Assuming a FSP participation rate between 50 and 60 percent, this finding implies that in 1993 there were somewhere between 3.5 and 5 million households eligible for the FSP but unaware of it. This fact suggests that an outreach program aimed at informing (eligible) nonparticipants of their eligibility could substantially increase FSP participation.

Recently, USDA has indicated a new interest in FSP outreach programs (*Nutrition Week*).[3] In addition, some States, such as Massachusetts, are now designing outreach programs to achieve target participation rates for the FSP and other assistance programs. This renewed interest in outreach may portend greater FSP expenditures on outreach. In that case, it may prove helpful to identify guidelines on how best to allocate a given outreach expenditure. This paper provides such an analysis for outreach programs that are designed to inform nonparticipants of their eligibility. Of course, FSP outreach efforts may include other types of activities, such as, for example, efforts to improve access and services. However, given the GAO finding that a large number of nonparticipating households lack knowledge of their eligibility, informational outreach programs will certainly be an important component of any successful outreach effort, a conclusion stressed by Coe.

Specifying the Optimal Number of Informational Outreach Contacts

Previous recommendations by the GAO and Coe suggest that informational outreach programs concentrate on groups of households with the greatest number of eligible nonparticipants who are unaware of their eligibility (denoted as "outreach households"). While the number of these households is an important measure of the potential response to informational outreach, it is not the only or the most important one. Simply knowing that it is eligible does not mean that a household will participate. This paper illustrates that the economically efficient use of informational outreach expenditures may require concentrating outreach efforts on groups of households with fewer but more responsive uninformed nonparticipants.

In its 1990 report, the GAO classified eligible nonparticipants in terms of marital status, race, age, and enrollment in other assistance programs. This report notes that eligible nonparticipating households headed by a single individual, more often than other household types, cite the lack of information as the principal reason for not participating in the FSP (pp. 4, 19). The lack of information about eligibility status by households headed by an unmarried individual is also supported by the regression results presented by Coe using PSID data (table 3, p. 1046).

Levedahl is an agricultural economist with the Food and Consumer Economics Division, ERS.

[1]Estimates of the FSP participation rate range between 25 percent and 60 percent depending on the data sources used, the methodologies employed, and the time period covered. A summary of previous estimates is given in Trippe.

[2]Sources are listed in the references section at the end of this article.

[3]Outreach programs designed to increase FSP participation have been authorized by Congress in both the Hunger Prevention Act of 1988 and in the Farm Act of 1990. However, until this year, USDA has not spent all the funds appropriated for outreach. This might be explained by a reluctance of States to engage in outreach activities, possibly because they can recover only half of their expenditures from the Federal Government.

Based on this finding, the optimal rules for allocating outreach expenditure are developed, in this paper, for a classification of low-income households (cash income less than 2.5 times the corresponding Federal poverty guidelines) stratified by the marital status of the head.[4] In the GAO classification by marital status, "households with a single head" refers to households whose head is an unmarried individual. This includes households with an unmarried couple living together. "Households with a married head" includes all other households. This includes households with married couples living together as well as households with heads who are divorced, widowed, or separated.

Let $i = 1, 2$ denote whether a low-income household has a single or married head, respectively. Define p_i as the probability that a household, from the ith group, decides to participate after an outreach contact. For the ith group, p_i is specified as follows. Define Y_i as a Bernoulli random variable that takes the value 1 with probability p_i if a household participates in the FSP because of the outreach contact (a success), otherwise Y_i takes a value 0 (a failure) with probability $1\text{-}p_i$. It follows that $E(Y_i) = p_i$. With this stochastic structure, the expected number of outreach contacts until success is constant even when households are sampled from a finite population without replacement. A proof of this proposition is given in Appendix A.

The optimal number of outreach contacts can be defined using the Lagrangian method. Denote the Lagrangian function by L.[5] The optimization problem becomes,

$$\max_{m_1,m_2,g} \quad L = m_1/t_1 + m_2/t_2 + g[C - c_1(m_1) - c_2(m_2)], \qquad (1)$$

such that $m_1 \leqslant N_1$ and $m_2 \leqslant N_2$, where,

m_i = the number of contacts of the ith group,
N_i = the total number of households in the ith group,
t_i = the expected number of outreach contacts until a household in the ith group participates. This number is constant, see Appendix A,
m_i/t_i = the expected number of FSP recipients resulting from m_i contacts,
c_i = the cost function associated with contacting households in the ith group,
C = the total budget available for outreach contacts, and
g = a Lagrangian multiplier.

An interior solution to (1) requires that m_1 and m_2 satisfy the following condition:

$$t_1MC_1 = t_2MC_2, \qquad (2)$$

where MC_i denotes the marginal cost of contacting households in the ith group. For the marital classification of households, (2) implies that the optimal number of contacts occurs when the expected (additional) cost per success is the same for either type of household.

Alternatively, since $1/t_i = p_i$, the solution (2) can also be written as,

$$p_1/MC_1 = p_2/MC_2, \qquad (3)$$

which implies that the optimal number of contacts is reached when any additional expenditure yields the same expected number of participants irrespective of the marital status of the household's head.

An Operational Version of the Optimal Number of Informational Outreach Contacts Rule

In this section, the decision rule (3), which maximizes the expected increase in FSP participation for a given outreach expenditure, is modified for application to the PSID data. This application requires estimates of the probability that an outreach contact results in FSP participation, p_i, and specific marginal cost functions.

Two Potential Marginal Cost Functions

Two possible marginal cost functions used to illustrate the decision rule (3) are given in table 1. The essential feature of any potential marginal cost function is that cost increases as the number of contacts increases. This property of a marginal cost function reflects the fact that low-income households are not equally accessible, and that those households that are easiest to contact are contacted first. Assuming increasing marginal cost does not, necessarily, exclude economies of scale.

[4]The groups need not encompass the entire eligible population. They may form a subset of this population. One example would be households with an elderly head. The model formulated does require, however, that the average FSP participation response of the groups differ. For example, households with an elderly head who is male can be expected, on average, to respond differently than ones with a female head.

[5]Conceptually, L is maximized assuming that the number of contacts is determined prior to the actual sampling of the households and is not updated. The efficient design of the outreach message is not an issue here. It is assumed that during the outreach contact actual eligibility can be determined, and any skeptical eligible nonparticipating household can be convinced of its eligibility.

Table 1—The optimal mix of contacts for alternative specifications of marginal cost function and a conditional probability of FSP participation by outreach households when they think they are eligible[a]

Marginal Cost	Optimal Mix (m_1/m_2)
Unconstrained Conditional Probability of FSP Participation	
(a) marginal cost for both groups increases at a constant rate a, $MC_i = am_i$	$m_1/m_2 = p_1/p_2$[b]
(b) marginal cost inversely related to the size of the group N_i, $MC_i = am_i/N_i$,	$m_1/m_2 = N_1p_1/N_2p_2$
Conditional Probability of FSP Participation Equals 1 (implied by GAO and Coe)	
(a1) MC as in (a)	$m_1/m_2 = p_{1o}/p_{2o}$[c]
(b1) MC as in (b)	$m_1/m_2 = n_{1o}/n_{2o}$[d]

a. An outreach household is one that is eligible but does not know it.

b. p_i is the probability that an informational outreach contact in the ith group results in participation. This probability is defined in (4).

c. p_{io} is the probability that a low-income household in group i is an outreach household.

d. n_{io} is the number of outreach households in group i.

Instead, economies of scale (if they exist) can be assumed to have been realized at contact levels below equilibrium. The two marginal cost functions in table 1 were chosen to yield a simple operational version of (3). Future studies may identify more accurate marginal cost functions to use with (3). However, for the purposes of illustrating how the participation decision of outreach households affects the allocation of outreach effort, these two marginal cost functions are adequate.

The first cost function, (a), specifies that the marginal cost of contacting either type of household is the same and increases at a constant rate. With this cost structure, (3) implies that the ratio of the optimal contacts equals the ratio of the success probabilities p_i. For example, if $p_1 = .15$ and $p_2 = .30$ the married group would be contacted twice as often as the singles.

The second cost function, (b), is characterized by a lower cost for larger groups. This function might reflect, for example, a lower marginal cost of contacting a population with greater density. For this marginal cost function, (3) implies that the ratio of the optimal contacts equals the ratio of the expected number of new FSP participants resulting from the outreach effort. This follows since the expected (potential) number of new FSP participants equals N_ip_i. The cost structure used in (1) assumes that the cost of contacting households with a married or single head are strictly separable. This assumption arises from the underlying scheme used to decompose the probability, p_i, that an informational outreach contact results in FSP participation. This scheme is discussed in the next section.

Specifying the Probability That an Informational Outreach Contact Results in FSP Participation

The stochastic specification of the probability that an informational outreach contact in the ith group results in FSP participation, p_i, was specified previously. Calculating this probability can be facilitated by decomposing it into the product of three separate probabilities, as follows,

$$\begin{aligned} p_i &= \text{Prob}(E_i = 1, R_i = 1, A_i = 1) \qquad (4) \\ &= \text{Prob}(E_i = 1)\text{Prob}(R_i = 1 | E_i = 1) \\ &\quad \text{Prob}(A_i = 1 | R_i = 1, E_i = 1) \\ &= e_i r_i a_i, \end{aligned}$$

so that the probability that an outreach contact in the ith group results in FSP participation is written as the product of the probability that the outreach contact in the ith group is with an eligible household, $\text{Prob}(E_i = 1) = e_i$, times the probability that an eligible household in the ith group is an outreach household (unaware of its eligibility), $\text{Prob}(R_i = 1 | E_i = 1) = r_i$, times the probability that an outreach household in the ith group participates once it thinks it is eligible, $\text{Prob}(A_i = 1 | R_i = 1, E_i = 1) = a_i$. The stochastic specifications underlying the events that make up this decomposition are specified in Appendix B.

The particular way in which the probability p_i has been decomposed in (4) assumes a specific procedure for identifying outreach households. In this decomposition, identification starts with sampling frames of low-income households (potential FSP recipients) with a single or married head, respectively. From these frames, eligible households are identified which are, in turn, used to sample for outreach households. Alternative decompositions are possible. For example, identification could start with a sampling frame that included all low-income households. In this case, an additional event reflecting the randomness of obtaining a household with a single or married head would be added to the decomposition. Correspondingly, an additional probability would be added to (4). The focus of this paper, however, is not on how to identify outreach households. Instead, this paper

stresses that differences in the participation response to outreach information influences the targeting and cost effectiveness of successful outreach expenditures.

Calculating the Relative Number of Informational Outreach Contacts Using PSID Data

In this section, probability estimates made using the decomposition outlined above are combined with each marginal cost function to derive implications for the optimal mix of informational outreach contacts using data from the PSID. This is done first to compare households with a married versus a single head, and then to compare single-male-headed households with those headed by a single female.

The data available in the PSID, or any other currently available survey, is not sufficient to calculate actual FSP eligibility.[6] However, the PSID is the only survey that records the household's self-evaluation of its FSP eligibility. Since data on a household's perceived eligibility are crucial to any analysis on the effect of informational outreach programs, this paper proceeds conditionally on the data and other conceptual limitations inherent in the PSID (GAO, 1988, p. 24).

Table 2 reports the number of households with a single or married head who are low-income, eligible, and outreach. Household FSP eligibility was estimated using the procedure employed by the GAO (1988, pp. 28-30). The limited availability of FSP deductible expenditures in the PSID was compensated somewhat by using the imputation equations from FNS's microsimulation MATH model to estimate the household's medical and child care deductions. These equations estimate these deductions based on the household's sociodemographic and economic profile.

Table 2 reports more outreach households (eligible but do not know it) with a single head (136) than with a married head (120). Qualitatively, this is the same result found by the GAO. The proportion of low-income households with a single head who

Table 2—Proportion and number of low-income, eligible, and outreach households by marital status[a]

	Households With A Single Head	Households With A Married Head
Low-Income Households		
Number	1370	1223
Eligible Households[b]		
Number	710	397
As a proportion of low-income households	.518	.325
Outreach Households[b]		
Number	136	120
As a proportion of eligible households	.192	.302

a. A low-income household is one with cash income less than 2.5 times the appropriate Federal poverty guideline. This definition is used by the Food and Nutrition Service in defining low-income households. Outreach households are eligible nonparticipating households who do not think they are eligible.
b. Eligibility is estimated using the procedure adopted by the GAO (1988, pp. 28-30). An outreach household is one that is estimated to be eligible but when asked, answers that it does not think it is eligible.

are eligible for the FSP (.518) is greater than for households with a married head (.325). However, a greater proportion of the households with a married head are outreach households (0.30 versus 0.19). Accordingly, the proportion of low-income households with a single or married head that are outreach households (.518×.190 versus .325×.300) are practically identical. This means that differences in the FSP participation response to informational outreach contacts will be due solely to differences in how these households respond to outreach information.

Estimating the Probability that an Informational Outreach Contact Results in FSP Participation

Table 3 summarizes the calculations of p_i for households with married or single heads. This probability was estimated using the decomposition (4). The probabilities in the decomposition were estimated using data from the PSID and are summarized in table 2. First, the probability that an outreach contact is with a eligible household, $\text{Prob}(E_i = 1)$, was estimated by the proportion of eligibility households in each low-income group. Then, the probability that an eligible household was also an outreach household, $\text{Prob}(R_i = 1 | E_i = 1)$, was estimated by the proportion of outreach households in each group of eligible households. Finally, the conditional probability of FSP participation that an outreach household participates when it thinks it is eligible, $\text{Prob}(A_i = 1 | R_i = 1, E_i = 1)$, was estimated using the

[6]See Trippe (table 4, p. 23) for an evaluation of the various surveys that have been used to estimate FSP eligibility. On this evaluation, the PSID is better than other surveys except the Survey of Income and Program Participation (SIPP). The primary limitation of the PSID for estimating eligibility is insufficient information on the household's assets, which results in overestimating the number of FSP-eligible households. A recent FNS report provides evidence that the overestimation may be large. In this report about 7.5 percent of the households that are eligible based on income criteria failed to pass the vehicle asset screen.

Table 3—Estimated probability that an informational outreach contact increases FSP participation by marital status and gender

Marital Status of Head	Number of Low-Income Households	(1) Pr(E = 1)[a]	(2) Pr(R = 1| E = 1)[b]	(3) Pr(A = 1| R = 1,E = 1)[c]	p_i^d
Single:	1370	0.518	0.192	0.500	0.050
Male	270	.393	.349	.430	.059
Female	1100	.550	.164	.530	.048
Married:	1223	.325	.302	.598	.059

a. Probability that a low-income household is eligible for the FSP.

b. Probability that an eligible household is an outreach household. An outreach household is defined as an eligible nonparticipating household which does not think it is eligible.

c. Probability that an outreach household participates in the FSP once it thinks it is eligible.

d. The probability that an outreach contact results in FSP participation and defined in (4). It is equal to the product of columns labeled (1) though (3).

results provided by Levedahl (forthcoming) and summarized in Appendix C. For each outreach household in the ith group, a conditional probability of FSP participation, if it thought it was eligible, was estimated. The sample mean of the ith group was used as an estimated of $\text{Prob}(A_i = 1 | R_i = 1, E_i = 1)$.[7]

Results From the Application of the Optimal Decision Rule

The marginal cost function (a) in table 1 implies that the low-income households with a married head should get almost 20 percent more contacts than the low-income households with a single head. This conclusion follows even though there are more single households who are eligible. Since low-income households with a married or a single head are equally likely to be outreach households ($\text{Prob}(E_1 = 1)\text{Prob}(R_1 = 1 | E_1 = 1) \approx \text{Prob}(E_2 = 1)$ $\text{Prob}(R_2 = 1 | E_2 = 1)$), the greater number of contacts of households with a married head, in this example, reflects the fact that these households are more likely to participate in the FSP when they thing they are eligible.

When group size affects marginal cost, as with marginal cost (b), the optimal mix changes but households with a married head still receive more contacts (approximately 6 percent) than households with a single head.

These results can be compared to the mix obtained from the recommendation implied by GAO and Coe. Both GAO and Coe indicate that the number of informational outreach contacts be determined according to the number of outreach households in each group. For the two cost functions, this recommendation results in the decision rules given in table 1 as (a1) and (b1), respectively. This recommendation maximizes the expected increase in FSP participation only if each outreach household participates once it thinks it is eligible—that is, only if the sole reason why an outreach household does not participate is that it is unaware of its eligibility. Or, equivalently, if $\text{Prob}(A_i = 1 | R_i = 1, E_i = 1) \equiv 1$. However, since this is not generally true, the recommendation implied by the GAO and Coe will not maximize FSP participation for a given expenditure.

Qualitatively, the GAO and Coe recommendation is opposite to those obtained from the general solution that puts no restrictions on $\text{Prob}(A_i = 1 | R_i = 1, E_i = 1)$. With the marginal cost function (a1), the GAO and Coe recommendation implies that households with a single head receive 1.2 percent more contacts than households with a married head. This difference increases to 13 percent with marginal cost function (b1).

With the single/married classification, group size has only a modest impact on the optimal mix of contacts. However, size can have a significant effect. This is illustrated by considering a classification of the households headed by a single individual into those with a male head and those with a female head. Using the marginal cost function (a), households headed by a single male should receive 23 percent more contacts than households headed by a single female. When the marginal cost of contact is allowed to vary inversely with group size (marginal cost (b)) the change is dramatic. In this case, households headed by a single male should receive just 30 percent of the contacts received by households headed by a single female.

[7]One might think that an improvement in the objective criterion is possibly by accounting for differences in the conditional probability of FSP participation within the groups. However, if the number of contacts is determined prior to the actual sampling, it can be shown that the group mean obtained after sampling will be equal to the original group mean. In other words, the same number of contacts is optimal whether or not differences in the response probabilities within the groups are considered.

Conclusion

The optimal proportion of informational outreach contacts that maximizes FSP participation for a given expenditure has been characterized. The optimal mix of contacts between households with a married or a single head is compared using two possible marginal cost functions. The results show that even though there are a greater number of outreach households headed by a single individual, economic efficiency requires that households headed by a married couple—since they are more responsive to informational outreach—be contacted more frequently. This conclusion is in contrast to previous recommendations implied by GAO and Coe that households headed by a single individual should be contacted more often.

Differences in group responsiveness are also likely to be important when determining the optimal contact mix for other sets of low-income households grouped along different sociodemographic dimensions. For example, it is well known that a relatively large proportion of eligible nonparticipating households have an elderly head (over 60 years old). However, elderly households also have a lower rate of participation in the FSP than other households facing similar economic circumstances, and are less likely than younger households to respond to any informational outreach effort. If this is the case, then, from the point of view of the overall FSP participation rate, those attempting to increase FSP participation by directing informational outreach programs at the elderly need to recognize that this effort may not be the most cost-effective use of outreach expenditure.

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Appendix A: Proof That the Expected Number of Outreach Contacts Until a Household Participates Is Constant

To prove this proposition, define the random variable X as the number of failures preceding the first success of a (0,1) Bernoulli random variable with an initial success probability p(1). From Feller (p. 210), X has a geometric distribution, $\text{Prob}(X = k) = (1-p(1))^k p(1)$ for $k = 0,1,2,\ldots$ where the expected number of contacts *before* the first success is given by, $E(X) = (1-p(1))/p(1)$. It follows that the first success is expected on the 1/p(1) contact.

The expected number of contacts until the second success, 1/p(2), can be calculated as follows. Let N denote the total number of households, and n the number of households who would participate if they knew they were eligible. Then, the expected number of contacts until the second success, 1/p(2), is,

$$1/p(2) = [N - 1/p(1)]/[n - 1] = 1/p(1).$$

By induction, the expected number of contacts between successes is constant even when households are sampled from a finite population without replacement.

Appendix B: The Stochastic Specification of the Events Underlying the Decomposition of the Probability that an Outreach Contact Results in FSP Participation

First, consider the stochastic specification of the random variable defining eligibility in the ith group. Define the random variable E_{ij} equal to 1, with probability e_i, if the jth low-income household in the ith group is eligible for the FSP, and equals 0 if not. The expected value of E_{ij} is e_i. Then, e_i is an estimate of the probability, $\text{Prob}(E_i = 1)$, that an outreach contact in the ith group is directed to a household eligible for the FSP.

Similarly, the stochastic specification of the random variable defining whether an eligible house-

hold in the ith group is an outreach household can be denoted as follows. Define the random variable R_{ij} equal 1, with probability r_i, if the jth eligible household in the ith group is an outreach household, and equals 0 if not. The expected value of R_{ij} is r_i. Then, r_i is an estimate of the probability, $Prob(R_i = 1| E_i = 1)$, that an eligible household in the ith group is an outreach household.

Finally, the stochastic specification of the random variable defining whether an outreach household in the ith group will participate in the FSP once it thinks it is eligible can be denoted as follows. Define the variable A_{ik} equal 1, with probability a_i, if the kth outreach household participates in the FSP when told it is eligible, and equals 0 if it does not. The expected value of A_{ik} is a_i. Then, a_i is an estimate of the probability, $Prob(A_i = 1| R_i = 1, E_i = 1)$, that an outreach household in the ith group participates in the FSP when told it thinks it is eligible.

Appendix C: Estimates of the Probability of FSP Participation Conditional on the Household Thinking It Is Eligible

Levedahl (forthcoming), using PSID data, estimated the probability of FSP participation conditional on the household's thinking it is eligible. This probability was specified to depend upon the difference between the food stamps that the household would receive, STAMPS, and the minimum number of food stamps the household requires in order to participate, S_{min}, plus a term, ANT, involving the household's ex-ante probability of FSP eligibility. The term involving this ex-ante probability adjusts for the fact that the estimating sample consists only of households which think they are eligible. Based on the stochastic specification in Appendix B, the conditional probability of FSP participation, for the jth household is defined (using the logistic function) as,

$$Prob(A_j = 1| R_j = 1, E_j = 1) = [1 + \exp(-(STAMPS_j - S_{min\,j} - cANT_j))]^{-1},$$

where c denotes a parameter to be estimated.

Using estimated values of the variable ANT, Levedahl (forthcoming) reports estimates of S_{min}, assumed to be a linear function of its determinants, plus the parameter c. These estimates are reported below with standard errors in parentheses. A list of determinants was obtained from previous studies of FSP participation. Definitions of the determinants used to specify S_{min} are given in table C.1. The variable STAMPS was calculated from FSP regulations using an estimate of the household's income (gross income – FSP deductions) used by FSP to calculate benefits.

$$\begin{aligned}
S_{min} = &-\underset{(60.37)}{0.93}\ \text{Intercept} + \underset{(30.21)}{40.06}\ \text{BLACK} \\
&+ \underset{(24.63)}{15.18}\ \text{HSPLUS} - \underset{(2.65)}{1.85}\ \text{REGION} \\
&- \underset{(63.72)}{315.92}\ \text{WELFARE} + \underset{(43.03)}{71.56}\ \text{EM_MALE} \\
&+ \underset{(42.48)}{99.29}\ \text{EM_FEM} + \underset{(46.48)}{78.82}\ \text{UNMARR_M} \\
&+ \underset{(48.23)}{34.72}\ \text{UNMARR_F} + \underset{(26.71)}{23.32}\ \text{HOME} \\
&- \underset{(26.02)}{12.79}\ \text{URBAN} + \underset{(33.83)}{87.15}\ \text{AGE60} \\
&- \underset{(9.71)}{13.06}\ \text{N_FU} - \underset{(27.82)}{16.92}\ \text{CHLT8};
\end{aligned}$$

$$c = -\underset{(2.65)}{5.42}$$

Table C.1: Variable names and definitions

Variable Name	Definition	
STAMPS:	predicted monthly dollar food stamp benefits	
BLACK	=1	if race of head is black
	=0	else
HSPLUS	=1	if head is at least a high school graduate
	=0	else
REGION	=1	if household located outside the South
	=0	else
EM_MALE	=1	if head of household is employed male
	=0	else
EM_FEM	=1	if head of household is employed female
	=0	else
WELFARE	=1	if household receives other welfare (AFDC, SSI, or other public welfare)
	=0	else
AGE60:		number of household members at least 60 years old
HOME	=1	if househoIf owns home
	=0	else
URBAN	=1	if household lives in a SMSA
	=0	else
ANT:		inverse of the predicted ex-ante probability of eligibility
UNMAR_F	=1	if head of household is unmarried female
	=0	else
UNMARR_M	=1	if head of household is unmarried male
	=0	else
CHLT8	=1	if children less than 8 years old are present
	=0	else
N_FU:		number of household members

Differences Among Commodities in Real Price Variability and Drift

Richard Heifner and Randal Kinoshita

Abstract. *Many farm products exhibit price variabilities over long time intervals that range between 10 and 20 percent when measured as standard deviations of annual rates of change. Price variability is notably higher for onions, rice, wool, oats, potatoes, grapefruit, and oranges, and lower for snap beans, tobacco, green peas, milk, broccoli, processing tomatoes, and strawberries. Price variability was higher during 1977-93 than during 1949-72 for grains, soybeans, and peanuts, lower for grapes, potatoes, processing tomatoes, and hogs, and about the same for other crops and livestock. Real prices fell between 1948 and 1993 for 29 of 30 commodities studied, with poultry, eggs, wool, snap beans, grains, and cotton exhibiting the largest rates of decline.*

Keywords. *Commodity prices, price trends, price variability, real prices.*

Differences among commodities in price variability and longterm price trends are important for private decisions about investments in farming and farm product marketing and for public decisions about farm programs. Knowledge of such differences can further our understanding of the fundamental changes underway in agriculture. This article uses price data going back for some commodities to as early as 1900 to describe and compare year-to-year price variability and changes in real price levels for 30 farm commodities selected to represent a cross section of U.S. agriculture.

Underlying this comparison of commodity differences is the notion that price variability is a natural and persistent characteristic of agricultural prices that can be quantified but not fully explained. Reducing price variability has been a longterm concern of agricultural policymakers, the goal of many government programs, and a focus of intense study (see Newbery and Stiglitz, for example).[1] Previous authors have found evidence of increasing price variability in U.S. agriculture during recent decades (see Edwards, Dalziell, Miller et al., and Myers and Runge). One of our objectives is to determine if increases in price variability broadly characterize U.S. agriculture or are confined to certain commodities.

Long price series are needed to detect persistent differences among commodities in price behavior. Fortunately, the National Agricultural Statistics Service and its predecessor agencies have reported prices for several major crops since before 1900, for most livestock since 1924, and for most fruits and vegetables since 1939. This analysis uses prices from as early as 1900 to the extent that they are available, but gives greatest attention to 1948-93.

Edwards noted that real wheat prices declined over much of the twentieth century. He pointed out that the decline was not continuous and the rate of decline that one measures depends upon the year one chooses as a starting point. Our analyses follow the spirit of Edwards' work. We cover 30 commodities, use annual rates of change to facilitate intercommodity comparisons, and include statistical tests of our assumptions and the differences observed between commodities and over time. We show that real prices for many agricultural commodities have declined over long periods, that price variability has changed for certain commodities, and that differences among commodities in price variability are persistent.

Data

Rates of change in real prices are used to show changes over long periods in real purchasing power, provide unit-free comparisons among commodities, and assure stationarity. Continuously compounded annual rates of change were calculated by taking first differences of logarithms

$$r_{t-1,t} = \log x_t - \log x_{t-1},$$

where $r_{t-1,t}$ is the rate of change in price from period t-1 to period t, x_t is the price in year t, and x_{t-1} is the price in year t-1.[2] This measure facilitates comparing price changes in different directions and over periods of different lengths. It is additive—the change over a period of length n

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[1]Sources are listed in the References section at the end of this article.

[2]The continuously compounded rate of change over a year can be converted to the simple annual rate of change by taking the antilog and subtracting 1. For example, the simple rate of change corresponding to a 0.05 compounded rate of change is the natural antilog of 0.05 minus 1, which is 0.05127 ...

equals the sum of the changes over the n subperiods:

$$r_{0,n} = \log x_n - \log x_0 = \sum_{t=1}^{n} (\log x_t - \log x_{t-1}) = \sum_{t=1}^{n} r_{t-1,t}.$$

Thus, a given rate of change in one year followed by an equal but opposite rate of change in the next year returns the series to its original level. Another advantage of using continuous annual rates of price change is that the standard deviation of such changes is the measure of price volatility used in options pricing models (See Black). This allows the price variabilities reported here to be compared with those reported in the options pricing literature.

Marketing year average prices received by farmers from 1900 (or the earliest year available) to 1993, were analyzed for the 30 commodities listed in table 1.[3] The price data are primarily from USDA's *Agricultural Statistics,* various issues, and from *Historical Statistics of the United States: Colonial Times to 1970.* The most recent prices are from USDA's *Agricultural Prices, 1992 Summary,* selected monthly issues of *Agricultural Prices* during 1993 and 1994, and *Crop Values, 1993 Summary.*[4]

U.S. average prices are calculated by weighting State prices by production prior to 1944 and by

[3]Marketing years for crops begin at the start of harvest and extend into the next calendar year for many commodities. Marketing years have been changed occasionally in the past and vary by State for some commodities. Marketing years for livestock coincide with calendar years except that marketing years begin in the preceding December for hogs, broilers, and eggs.

[4]For information on how the prices were collected, see USDA, *Major Statistical Series of the U.S. Department of Agriculture.*

Table 1—Changes in real levels of selected commodity prices and price indexes, with comparisons, 1949-1993

Commodity	Nominal prices		Real prices		Real price changes	
	1948	1993	1948	1993	Total, percent	Annual, percent
Wheat, $/bu.	1.98	3.20	9.95	2.57	–74.21	–3.01
Rice, $/cwt.	4.88	9.00	24.52	7.21	–70.57	–2.72
Corn, $/bu.	1.28	2.60	6.43	2.08	–67.59	–2.50
Oats, $/bu.	.72	1.40	3.60	1.12	–68.54	–2.59
Grain sorghum $/bu.	1.28	2.41	6.43	1.93	–69.96	–2.67
Soybeans, $/bu.	2.27	6.50	11.40	5.21	–54.31	–1.74
Cotton, cents/lb.	30.38	54.30	152.62	43.53	–71.48	–2.79
Tobacco, cents/lb.	.48	1.75	2.42	1.40	–42.07	–1.21
Peanuts, cents/lb.	10.50	29.80	52.75	23.89	–54.72	–1.76
Oranges, $/box[1]	1.75	5.04	8.79	4.16	–52.66	–1.70
Grapefruit, $/box[1]	.83	4.28	4.17	3.53	–15.24	–0.38
Grapes, $/ton	38.50	289.00	193.42	231.66	19.77	0.40
Strawberries, $/cwt.	22.20	52.50	111.53	42.08	–62.27	–2.17
Broccoli, $/cwt.	9.38	25.90	47.12	20.76	–55.94	–1.82
Lettuce, $/cwt.	4.04	16.00	20.30	12.83	–36.81	–1.02
Onions, $/cwt.	2.64	15.80	13.26	12.67	–4.51	–0.10
Tomatoes, fresh, $/cwt	6.10	31.60	30.65	25.33	–17.34	–0.42
Potatoes, $/cwt.	2.53	6.22	12.71	4.99	–60.77	–2.08
Beans, snap, $/ton	122.22	178.00	614.01	142.69	–76.76	–3.24
Peas, green, $/ton	90.05	251.00	452.40	201.20	–55.53	–1.80
Tomatoes, proc., $/ton	27.92	60.10	140.27	48.18	–65.65	–2.37
Cattle, $/cwt.	22.20	73.32	111.53	58.77	–47.30	–1.42
Steers, Choice, $/cwt[2]	28.88	76.36	143.27	61.21	–60.04	–2.04
Hogs, $/cwt.	23.10	45.26	116.05	36.28	–68.74	–2.58
Lambs, $/cwt.	22.80	64.81	114.54	51.95	–54.64	–1.76
Milk, $/cwt.	4.88	12.83	24.52	10.28	–58.05	–1.98
Wool, cents/lb.	49.20	50.00	247.17	40.08	–83.78	–4.04
Broilers, cents/lb.	36.00	33.96	180.86	27.22	–84.95	–4.21
Turkeys, cents/lb.	46.80	38.90	235.12	31.18	–86.74	–4.49
Eggs, cents/dozen	47.20	62.39	237.13	50.01	–78.91	–3.46
Crops, index	255	531	1281.1	425.6	–66.77	–2.45
Livestock, index	315	779	1582.5	625.4	–60.54	–2.07
All commodities, index	287	653	1441.8	523.4	–63.70	–2.25
Prices paid, index	260	1346	1306.2	1079.0	–17.40	–0.42

[1]Final year is 1992.
[2]Composite of Chicago prices 1935-50, Omaha prices 1951-69, and Nebraska direct prices for 1970-93.

quantity sold from 1944 to 1993. Prices for grains prior to 1979 include allowances for loans outstanding and government purchases, where applicable. Cotton prices are for all cotton, gross weight prior to 1964 and net weight since, and include allowances for unredeemed loans during 1974-78. Orange and grapefruit prices are returns per box at the packinghouse door. Prices at the processing plant door are used for snap beans, green peas, and tomatoes for processing. Prices are on an f.o.b. basis for lettuce, onions, and tomatoes for fresh use. Strawberry and broccoli prices apply to both processing and fresh markets. Choice steer prices are for Chicago delivery from 1935 to 1950, Omaha delivery from 1951 to 1969, and Nebraska direct for 1970 to 1993, as reported by the Agricultural Marketing Service.

The available price series vary in length for the different commodities. Prices for wheat, corn, oats, cotton, tobacco, potatoes, and wool begin in 1900. Rice prices start in 1904, soybean prices in 1924, and grain sorghum prices in 1929. The series begin in 1924 for grapes, in 1929 for citrus fruits, and in 1939 for most vegetables. Livestock prices, except for Choice steers, are average prices received by farmers and they begin in 1924. Egg, turkey, and broiler prices begin in 1909, 1929, and 1934, respectively. Milk prices are prices of all milk wholesale beginning in 1910. Prices for 1993 are preliminary for all commodities.

Prices were deflated using the implicit gross domestic product (GDP) deflator (1987=100). Deflating has only a minor effect on measures of short-term variability because year-to-year changes in inflation rates generally have been small compared with year-to-year commodity price changes.[5] The implicit price deflator was obtained for recent years from the *Economic Report to the President,* selected issues. The deflator was extended backward to earlier years using GNP deflators, and Consumer Price Index estimates prior to 1929, reported in *Business Statistics, 1961-88,* a supplement to the *Survey of Current Business,* and in the *Historical Statistics of the United States: From Colonial Times to 1970.*

Historical Declines in Real Prices

Twenty-nine of the 30 commodities analyzed exhibited declines in real prices between 1948 and 1993 (table 1). The total percentage declines are large for many commodities—over 80 percent for turkeys, broilers, and wool, and about 70 percent for the grains and cotton, for example.[6] The corresponding average annual rates of decline were over 4 percent for turkeys, broilers, and wool, over 3 percent for eggs and snap beans, and 2½ to 3 percent for the grains, cotton, and hogs. Prices for the remaining commodities declined at a 1 to 2½ percent rate except for onions and processing tomatoes where the rate was less than 1 percent. Grapes exhibited a slight increase.

To provide a broad gauge of farm price changes for comparison, we include base 1910-14 indexes of prices received by farmers for crops, livestock, and all commodities and prices paid by farmers (bottom of table 1). To eliminate the effects of general price inflation on the indexes, they too were divided by the implicit GDP deflator. This measure shows a total decline between 1948 and 1993 in real prices of all farm commodities of 63.70 percent and an average rate of decline of 2.25 percent. The average rate of decline was 2.45 percent for crops and 2.07 percent for livestock. Prices paid by farmers declined at a 0.42 percent rate.

Real prices of most agricultural commodities have declined during much of the twentieth century. Table 2 shows average rates of change in real prices for three 24-year intervals starting in 1901, and for the 21-year interval 1973-93. The 1901-24 interval includes only the seven commodities for which prices were reported as early as 1900. Real prices for wheat, oats, and potatoes declined during this early period while real prices for corn, cotton, tobacco and wool increased.

The 1925-48 interval uses data from the first year when livestock prices were widely reported, and spans the Depression, the drought of the thirties, and World War II. Real prices for food grains, tobacco, peanuts, potatoes, meat animals, milk, and eggs rose during this interval while real prices for feed grains, soybeans, cotton, grapes, and wool declined.

The 1949-72 interval covers the period between mid-century and the U.S. abandonment of the gold standard. Real prices declined during this interval for 27 of the 30 commodities analyzed. Rates of decline exceeded 4 percent for broilers, turkeys, eggs, and wool and exceeded 3 percent for wheat, cotton, and snap beans. The decline in soybean

[5]Between 1948 and 1993 the inflation rate, as measured by changes in logarithms of the GDP deflator, averaged 4.08 percent with a standard deviation of 2.38 percent, and a maximum of 9.57 percent.

[6]The total percent change equal 100 × (1993 price ÷ 1948 price) − 100 while the annual rate of change is calculated by the formula above. Note that only the initial price and the final price are needed to calculate total or average change, but that the intermediate prices are needed to calculate the standard deviation of price changes and the standard error of the estimated average price change.

Table 2—Average annual rates of change in real prices, selected commodities and time intervals, percent

Commodity	1901-1924	1925-1948	1949-1972	1973-1993
Wheat	-0.20	0.08	-3.27	-2.71
Rice	—	0.21	-1.44	-4.18
Corn	1.50	-1.05	-1.93	-3.16
Oats	-0.46	-0.14	-2.74	-2.42
Grain sorghum	—	—	-2.50	-2.87
Soybeans	—	-2.17	-0.05	-3.67
Cotton	0.71	-0.66	-3.23	-2.29
Tobacco	1.23	2.05	-0.52	-2.01
Peanuts	—	0.65	-1.44	-2.13
Oranges	—	—	-0.99	-2.55[1]
Grapefruit	—	—	2.13	-3.39[1]
Grapes	—	-1.77	3.28	-2.89
Strawberries	—	—	-2.46	-1.83
Broccoli	—	—	-2.19	-1.40
Lettuce	—	—	-1.32	-0.67
Onions	—	—	-0.96	-1.32
Tomatoes, fresh	—	—	0.91	-1.95
Potatoes	-1.18	1.49	-2.04	-2.12
Beans, snap	—	—	-3.62	-2.82
Peas, green	—	—	-1.87	-1.72
Tomatoes, proc.	—	—	-1.82	-3.01
Cattle	—	3.73	-1.07	-1.83
Steers, Choice	—	—	-2.12	-1.94
Hogs	—	2.96	-2.44	-2.75
Lambs	—	1.28	-1.76	-1.75
Milk	—	1.45	-1.87	-2.00
Wool	0.98	-0.60	-4.20	-3.86
Broilers	—	—	-6.69	-1.38
Turkeys	—	—	-5.89	-2.89
Eggs	—	0.54	-4.55	-2.22
Crops, index	—	—	-2.75	-2.11
Livestock, index	—	—	-2.09	-2.04
All commod., index	—	1.07	-2.42	-2.06
Prices paid, index	—	0.19	-0.73	-0.07

–Data not available
[1]1973-1992

prices was negligible. Real prices for grapefruit, grapes, and tomatoes for fresh use increased.

Real prices for all 30 commodities declined during 1973-93 with 20 of the 30 commodities exhibiting rates of decline exceeding 2 percent annually. The rate of decline exceeded 4 percent for rice and 3 percent for wool, soybeans, grapefruit, corn, and processing tomatoes. Rates of decline were less than during 1949-72 for poultry, eggs, wheat, and cotton, and greater for rice, corn, soybeans, tobacco, peanuts, oranges, grapefruit, and tomatoes.

These declines in real prices are consistent with the hypothesis that increases in productivity have outpaced increases in demand allowing larger quantities to be produced and consumed at lower real prices. However, the year-to-year variability in prices makes it impossible to project rates of decline for individual commodities with much certainty, as will be shown below.

Historical Differences Among Commodities in Price Variability

The standard deviations of real price changes are reported in table 3 for the same intervals as shown in table 2. In addition, the last column of the table shows standard deviations for 1977-93, which excludes the years of unusually high price volatility during the mid-seventies. The 1977-93 standard deviations are shown in fig. 1 with the commodities ordered according to their respective price variabilities. Standard deviations of price changes by decade are displayed in table 4.

Price variability was higher prior to 1949 than it has been since for most crops where price data for the earlier years are available. For example, corn, cotton, and potato price variability exceeded 30 percent from 1901 to 1924 and corn, oats, soybean, potato, and grape price variability exceeded 30 percent from 1925 to 1948. Hog price variability has been substantially less in recent years than

Table 3—Standard deviations of rates of change in real prices, selected commodities and time intervals, percent

Commodity	1901-24	1925-48	1949-72	1973-93	1977-93
Wheat	18.00	25.43	10.97	24.84	17.70
Rice	—	22.79	9.79	32.72	29.97
Corn	41.64	31.86	12.45	21.65	19.74
Oats	23.11	32.43	9.14	26.27	26.25
Grain sorghum	—	—	13.49	20.95	19.06
Soybeans	—	33.08	10.11	20.61	18.72
Cotton	31.74	27.97	13.27	17.68	14.60
Tobacco	22.26	22.30	4.94	5.59	4.05
Peanuts	—	23.80	5.18	10.14	11.12
Oranges	—	—	25.32	21.22[1]	23.51[1]
Grapefruit	—	—	32.89	22.76[1]	24.80[1]
Grapes	—	34.35	25.15	13.74	14.21
Strawberries	—	—	8.78	7.28	7.70
Broccoli	—	—	5.60	6.43	6.55
Lettuce	—	—	14.46	15.27	15.17
Onions	—	—	39.73	36.48	34.79
Tomatoes, fresh	—	—	9.23	9.55	10.62
Potatoes	37.47	49.67	36.78	25.91	25.10
Beans, snap	—	—	4.55	9.43	3.36
Peas, green	—	—	4.27	11.10	4.52
Tomatoes, proc.	—	—	10.18	11.49	6.89
Cattle	—	13.27	13.11	13.35	11.75
Steers, Choice	—	—	11.17	10.58	9.49
Hogs	—	25.44	18.77	16.50	13.48
Lambs	—	13.80	10.74	10.91	11.36
Milk	—	8.80	6.37	6.08	5.24
Wool	27.36	28.14	27.05	33.29	26.41
Broilers	—	—	9.73	15.39	10.13
Turkeys	—	—	10.95	18.32	12.18
Eggs	—	14.28	13.91	15.88	12.24
Crops, index	—	—	4.93	12.77	7.96
Livestock, index	—	—	7.94	9.29	6.99
All commodities, index	—	12.13	5.70	9.19	5.85
Prices paid, index	—	4.14	1.95	3.01	2.27

–Data not available.
[1]Final year is 1992.

prior to 1949 while price variability for cattle and lambs is down slightly.

Most grains and soybeans exhibited price variabilities below 10 percent during the 1950's and 1960's (see app. table 1). Price variabilities for these commodities jumped to the 20 percent range or higher in the seventies, and have remained high during the eighties and nineties. Rice and oats prices have been particularly volatile during this recent period.

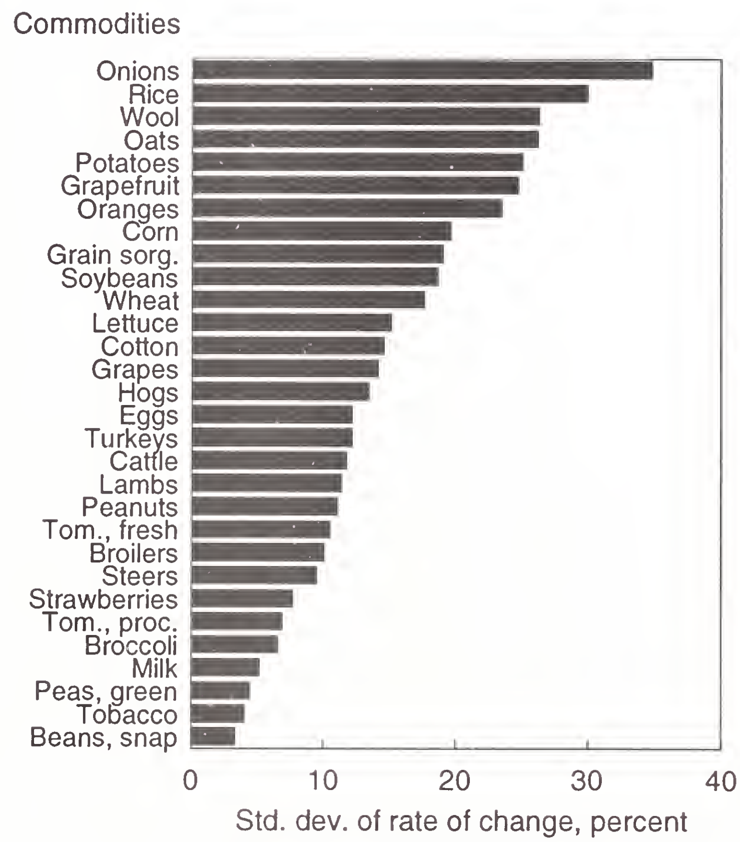
Several commodities have exhibited price variabilities exceeding 20 percent during many decades. These include onions, potatoes, wool, oranges, and grapefruit. At the other extreme are milk, tobacco, processing vegetables, broccoli, and strawberries where price variability has been consistently below 10 percent. Price variabilities for meat animals and eggs have been in the 10-20 percent range since 1949. Variabilities of the indexes of prices received are smaller than the averages of the variabilities of the included commodities because the commodity prices included in each index are not perfectly correlated.

Stationarity in Prices and Price Changes

We turn now to the question of whether the historical patterns of drift and variability of price changes are likely to continue. To forecast a stochastic process one must determine that it is stationary, or transform it to a stationary process, and quantify the probability distribution that the stationary process follows. Stationarity in the prices and price differences was tested by applying the Dickey-Fuller t test for unit roots to the longest series available for each commodity.[7] This

[7]A unit root is present if the first order autocorrelation coefficient for a series is 1, which is the condition for a random walk. In such cases, the coefficient of the regression of the first difference in the series on the lagged value of the series is zero. The essence of the Dickey-Fuller test is to test this regression coefficient for difference from zero using special tables that they provide.

Figure 1
Price variability by commodity, 1977-93



is a test of whether a series tends to converge toward its mean or trend level. The augmented test was used, which in this application involves regressing the first difference of the series being tested on the lagged value of the series plus a constant, a trend, and two lagged first differences.[8] The tests were applied to the original price series, the logarithms of deflated prices, and the first differences of the logarithms of deflated prices.

Unit roots in the nominal prices could be rejected at the 10 percent or higher level for only 3 of the 30 commodities (table 5). When the series were deflated and converted to logarithms, unit roots were rejected at the 10 percent or higher level for 15 commodities. Unit roots in the first differences of logarithms were rejected for all 30 commodities and all 4 price indexes at the 1 percent level. These results show that the rates of change series are more certain to have bounded variances than the undifferenced series and support the use of rates of change (first differences of logarithms) in our analyses.

Normality of Price Changes

In addition to stationarity, normality is required to test hypotheses about means and variances. Deviations from normality in the price changes were evaluated by calculating skewness, kurtosis, and the Jarque-Bera statistic using 1949-1993 observations for each series (table 6). The Jarque-Bera test is significant at the 20 percent level indicating non-normality for 13 commodities, wheat, rice, oats, cotton, grapes, onions, snap beans, green peas, processing tomatoes, milk, broilers, turkeys, eggs, and all of the price indexes. The sample distributions for all of these series exhibit thick tails as evidenced by kurtosis exceeding 3, its value under normality. Inspection of the data suggests that 1 to 3 outlying observations for each commodity account for most of the kurtosis. When these outliers are dropped from the sample, normality is no longer rejected for 11 of the 13 commodities and for all 4 indexes (table 7). Outliers are not removed for oats and cotton because they cannot be clearly distinguished.

The results suggest that annual price changes are approximately normally distributed for most agricultural commodities. However, more than a third of the commodities exhibited extreme price movements one or more times during the 45-year sample period. Many of the outliers were for the years 1973 and 1974 when the first large grain sales were made to the Soviet Union following the United States' abandonment of gold convertibility. To avoid undue influence from extreme observations, outliers were omitted or post-1975 data were used in several of the statistical tests reported below.

Prospects for Continued Declines in Real Price Levels

The historical observations reported in tables 1 and 2 combined with the evidence of stationarity in price changes shown in table 5 suggest that real prices for many agricultural commodities are likely to continue to drift downward. However, the downward drifts in real prices generally are small relative to their standard errors making it impossible to conclude with a high degree of confidence that real prices for any particular commodity will continue to decline. T ratios to test for zero price drift (table 8) were calculated for each commodity by dividing the mean rate of price change for 1949-93 by its standard error. The t ratio for the all commodity index is large enough in absolute value to reject the hypothesis of zero drift at the 5

[8] The unit root, normality, and homoscedasticity tests were calculated using MicroTSP, Version 7.0, written by David M. Lilien and distributed by Quantitative Micro Software of Irvin, CA.

Table 4—Standard deviations of rates of change in real prices by decade, 1901-10 to 1971-80 and for 1981-93, percent

Commodity	01-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-93
Wheat	16.10	16.90	22.41	34.54	12.71	4.36	14.10	30.94	17.80
Rice	—	35.92	16.04	28.25	19.71	9.70	4.73	31.57	32.27
Corn	27.36	54.28	28.88	41.69	24.02	5.93	9.22	24.02	21.82
Oats	23.70	23.77	20.01	45.08	22.28	9.65	5.79	22.59	27.46
Sorghum	—	—	—	49.58	24.73	16.69	8.35	21.26	20.72
Soybeans	—	—	—	46.28	22.93	6.54	8.23	22.14	20.29
Cotton	20.69	41.94	34.67	28.06	19.62	6.47	13.89	19.25	14.76
Tobacco	8.61	31.31	19.84	27.05	18.30	3.77	5.63	6.36	4.27
Peanuts	—	28.57	21.26	32.46	11.97	7.05	3.10	6.04	11.95
Oranges[1]	—	—	—	37.30	35.77	21.17	31.73	19.29	21.93
Grapefruit[1]	—	—	—	37.32	52.64	17.88	37.70	13.92	27.47
Grapes	—	—	—	27.39	47.23	23.62	18.47	19.94	14.99
Strawb.	—	—	—	—	27.40	11.83	6.64	6.78	7.32
Broccoli	—	—	—	—	22.94	5.77	4.53	5.48	7.28
Lettuce	—	—	—	—	23.62	9.3	13.97	19.57	12.76
Onions	—	—	—	—	52.24	51.27	28.79	47.34	26.55
Tom. fresh	—	—	—	—	18.57	10.12	7.92	9.16	10.79
Potatoes	33.48	44.99	55.29	56.72	25.16	45.93	30.62	31.15	23.33
Bean, snap	—	—	—	—	15.69	5.31	3.33	13.69	3.58
Peas, green	—	—	—	—	12.55	3.43	4.91	15.65	4.67
Tom. proc.	—	—	—	—	15.88	8.45	12.89	15.37	6.26
Cattle	—	—	—	16.68	9.79	18.29	6.50	18.19	7.21
Steers	—	—	—	—	10.16	14.35	7.26	13.62	6.67
Hogs	—	—	—	31.78	20.52	20.01	14.52	24.24	13.36
Lambs	—	—	—	14.80	7.11	12.93	8.60	8.42	11.76
Milk	—	7.50	9.44	10.43	10.75	6.80	3.70	5.09	5.27
Wool	16.57	21.99	37.32	40.17	12.55	29.07	13.13	44.24	30.08
Broilers	—	—	—	—	13.07	10.51	9.58	18.73	11.36
Turkeys	—	—	—	17.42	17.82	8.54	12.46	23.05	12.51
Eggs	—	9.21	12.71	14.20	16.74	16.59	10.55	19.76	13.32
Crops	—	—	—	—	12.70	5.46	3.77	15.40	8.92
Livestock	—	—	—	—	9.91	9.37	5.80	13.01	4.75
All commod.	—	9.74	13.91	15.36	10.62	6.89	3.25	11.98	5.32
Prices paid	—	2.73	5.41	2.45	5.84	2.70	0.99	2.96	1.69

—Data not available.
[1]Last year is 1992.

percent level, but only a few of the t ratios for individual commodities are so large.[9]

No clear pattern of rising or falling rates of price change is evident in the data. Twenty-seven of the 30 commodities exhibited real price declines from 1949 to 1972, all 30 exhibited declines from 1973 to 1993, and 17 exhibited larger rates of decline during the latter period. To test whether the rates of price change are rising or falling over time, each series of price changes was regressed on time. The regression coefficients are negative for all crops that have been under Government support programs and mixed for other commodities, but none of the coefficients differ from zero at the 10 percent level of statistical significance (column 3 of table 8).

[9]Similar results were obtained when t ratios were calculated separately for the 1949-72 and 1977-93 intervals to eliminate the large price shocks of the mid-seventies.

We conclude that the downward drift in prices is strong and likely to persist for agricultural commodities as a group, but expected rates of change for most individual commodities are subject to much uncertainty. Moreover, the differences in rates of change between commodities generally are not statistically significant.

Changes Over Time in Price Variability

Three tests were performed to determine if prices are becoming significantly more or less variable over time. White tests and ARCH tests were applied to the residuals from the regressions of price changes on time. The White test is a test for relationships between the squared residuals and the independent variables in a regression. The White test on the residuals rejected homoscedasticity at the 10 percent level or higher for rice, corn, oats, soybeans, peanuts, grapefruit, grapes, potatoes, and milk (column 4 in table 7).

Table 5—Dickey-Fuller t-statistics on nominal prices and logarithms and first differences of logarithms of real prices, selected commodities, and designated time intervals

Commodity	Years included	Nominal price	Log real price	First difference log real price
Wheat	1904-93	–2.92	–3.18+	–6.51**
Rice	1907-93	–3.32+	–2.41	–7.80**
Corn	1904-93	–3.20+	–3.71*	–7.34**
Oats	1904-93	–2.92	–3.19+	–6.82**
Grain sorghum	1932-93	–2.98	–3.72*	–6.71**
Soybeans	1927-93	–2.58	–2.47	–7.56**
Cotton	1904-93	–2.33	–3.10	–7.95**
Tobacco	1904-93	–1.50	–2.81	–7.90**
Peanuts	1912-93	–1.17	–2.37	–8.06**
Oranges	1932-92	–2.20	–3.76*	–7.19**
Grapefruit	1932-92	–2.70	–5.16**	–5.65**
Grapes	1927-93	–2.07	–3.55+	–5.87**
Strawberries	1942-93	–1.58	–5.78**	–4.87**
Broccoli	1942-93	–1.67	–3.98*	–4.19**
Lettuce	1942-93	–1.58	–4.10*	–5.89**
Onions	1942-93	–1.56	–3.48+	–8.92**
Tomatoes, fresh	1942-93	0.10	–3.81*	–5.34**
Potatoes	1904-93	–2.31	–4.20**	–8.67**
Beans, snap	1942-93	–2.35	–6.65**	–5.33**
Peas, green	1942-93	–1.59	–3.54*	–5.20**
Tomatoes, proc.	1942-93	–1.88	–2.84	–5.34**
Cattle	1927-93	–1.68	–2.74	–6.29**
Steers, Choice	1938-93	–1.80	–2.90	–6.60**
Hogs	1927-93	–2.29	–2.40	–7.50**
Lambs	1927-93	–2.56	–2.71	–5.33**
Milk	1913-93	–1.55	–2.05	–6.50**
Wool	1904-93	–3.54*	–2.78	–6.86**
Broilers	1937-93	–1.32	–1.84	–5.19**
Turkeys	1932-93	–2.01	–2.14	–6.77**
Eggs	1912-93	–2.59	–2.22	–7.67**
Crops	1937-93	–1.96	–2.56	–5.41**
Livestock	1937-93	–1.41	–2.50	–6.41**
All commodities	1914-93	–1.49	–2.55	–6.48**
Prices paid	1914-93	–0.17	–2.98	–5.84**

**,*, and + indicate that unit roots are rejected at the 1, 5, and 10 percent levels of statistical significance, respectively.

The ARCH test is a test of whether large residuals follow large residuals and small residuals follow small residuals (See Engle). It involves regressing squared residuals on lagged squared residuals. Three lags were used in the test. The tests indicate significant serial dependence in variances at the 10 percent level or higher for corn, oats, tobacco, peanuts, grapefruit, hogs, wool, and the index of livestock prices (column 5 of table 8).

An F test for differences in variance between 1977-1993 and 1949-1972 was applied to each series. The larger of the two variances was used in the numerator for each test. Significantly larger variances were found during 1977-93 than during 1949-72 for all the grains, soybeans, peanuts, and the crop price index, while grapes, potatoes, processing tomatoes, and hogs exhibited significantly lower variances during the later period (last column of table 8). These test results suggest that price variabilities have changed for enough commodities that the 1977-93 variability estimates are to be preferred over the 1949-93 estimates for making projections.

Differences Among Commodities in Price Variability

Many of the differences in price variability among commodities shown in fig. 1 and tables 3 and 6 are larger than would be expected due solely to sampling error and appear to reflect inherent differences among the commodities. Differences in price variability between pairs of commodities can be evaluated using the F statistic. The 10 percent critical value for $F(16, 16)$, which is applicable to the 1977-1993 interval, is 1.93. Its square root, 1.39, can be used to test for differences in the standard deviations shown in the last column of table 3. The average standard deviation for the 30 commodities during 1977-1993 is 13.55. Thus, we can say with about 90 percent confidence that variabilities exceeding $13.55 \times 1.39 = 18.83$ are

Table 6—Standard deviations, skewness, kurtosis, and tests for normality in rates of change in real prices, selected commodities, 1949-93

Commodity	Standard deviation, percent	Skewness	Kurtosis	Jarque-Bera statistic	Probability
Wheat	18.53	1.49	8.28	68.84	.00
Rice	23.21	0.69	4.75	9.28	.01
Corn	17.16	0.22	3.13	0.39	.82
Oats	18.90	–0.26	4.90	7.29	.03
Grain sorghum	17.17	0.11	2.41	0.75	.69
Soybeans	15.81	–0.17	3.02	0.22	.89
Cotton	15.31	0.43	4.16	3.97	.14
Tobacco	5.25	–0.30	3.50	1.15	.56
Peanuts	7.80	–0.12	4.02	2.07	.36
Oranges[1]	23.29	0.03	2.19	1.22	.54
Grapefruit[1]	28.55	0.19	3.43	0.60	.74
Grapes	20.64	0.21	4.67	5.55	.06
Strawberries	8.03	–0.53	3.15	2.15	.34
Broccoli	5.95	–0.18	2.53	0.67	.71
Lettuce	14.67	0.08	2.22	1.18	.55
Onions	37.83	–0.71	3.94	5.46	.07
Tomatoes,	9.38	–0.15	2.73	0.30	.86
Potatoes	31.82	0.10	3.13	0.11	.95
Beans, snap	7.17	2.99	16.61	414.19	.00
Peas, green	8.10	3.36	19.13	572.37	.00
Tomatoes,	10.71	1.09	4.59	13.56	.00
Cattle	13.07	–0.28	3.86	1.96	.38
Steers, Choice	10.78	–0.41	3.85	2.62	.27
Hogs	17.54	0.07	2.43	0.62	.73
Lambs	10.69	–0.54	2.53	2.60	.27
Milk	6.16	–0.40	4.17	3.76	.15
Wool	29.77	0.25	3.19	0.52	.77
Broilers	12.82	1.14	6.72	35.73	.00
Turkeys	14.75	0.50	5.51	13.65	.00
Eggs	14.73	0.74	4.44	8.06	.02
Crops	9.32	1.52	8.24	68.55	.00
Livestock	8.50	.70	3.46	4.09	.13
All commodities	7.44	1.60	8.35	72.90	.00
Prices paid	2.49	1.00	5.31	17.57	.00

[1]1949-92.

Table 7—Standard deviations, skewness, kurtosis, and tests for normality in rates of change in real prices, commodities exhibiting nonnormality in previous table, 1949-93 with outlying observations omitted

Commodity	Years omitted	Standard deviation, percent	Skewness	Kurtosis	Jarque-Bera statistic	Probability
Wheat	73	14.42	0.02	3.47	0.41	.81
Rice	73, 86, 87	16.75	.05	3.29	.17	.92
Grapes	50, 51, 73	16.70	.19	3.42	.57	.75
Onions	53	33.24	–.15	2.42	.78	.68
Beans, snap	74	4.47	.04	2.67	.21	.90
Peas, green	74	4.73	.03	3.69	.89	.64
Tomatoes, proc.	74	9.21	.52	2.70	2.16	.34
Milk	49, 91	5.15	.42	3.29	1.40	.50
Broilers	73	10.29	–.26	2.18	1.73	.42
Turkeys	73, 74	11.53	–.39	3.13	1.11	.58
Eggs	73	12.73	.02	2.48	.50	.78
Crops	73, 74	6.70	–.31	3.31	.87	.65
Livestock	73, 74	7.31	.47	2.38	2.23	.34
All commodities	73, 74	5.79	.07	2.60	.32	.85
Prices paid	73, 74	2.02	.27	4.28	3.43	.18

Table 8—Statistics for testing drift and variability of price changes, 1949-93

Commodity	t ratio, test for zero drift	Regression of rates of change on time: Regression coefficient	F for White test	F for ARCH test	F for variance ratio, 1977-93 vs. 1949-72[1]
Wheat	–1.09	–.028	1.22	.03	2.60*
Rice	–.79	–.044	2.60+	1.24	9.38**
Corn	–.98	–.030	2.93+	2.35+	2.51*
Oats	–.92	–.045	3.51*	3.07*	8.25**
Sorghum	–1.04	–.019	1.00	1.29	2.00+
Soybeans	–.74	–.063	4.60*	1.86	3.43**
Cotton	–1.22	–.078	.64	.13	1.21
Tobacco	–1.55	–.073	.55	2.84+	1.48
Peanuts	–1.51	–.026	6.28**	3.11*	4.61**
Oranges[1]	–.48	–.213	.48	.55	1.16
Grapefruit[1]	–.09	–.238	3.39**	2.30+	1.76
Grapes[1]	.13	–.097	3.19+	.92	3.13*
Strawberries	–1.81+	.049	.88	.79	1.30
Broccoli	–2.06*	.046	1.65	.15	1.37
Lettuce	–.47	.044	.21	1.40	1.10
Onions[1]	–.02	.047	1.26	.41	1.30
Tom. fresh	–.30	–.062	2.35	.96	1.32
Potatoes	–.44	.077	2.48+	.15	2.15+
Beans snap	–3.03*	0	.61	.12	1.84
Peas green	–1.49	–.031	.64	.06	1.12
Tom. proc.	–1.49	–.095	.76	.11	2.19+
Cattle	–.73	.044	1.07	.38	1.24
Steers	–1.27	.051	1.48	.54	–1.39
Hogs	–.99	.017	1.07	2.61+	1.94+
Lambs	–1.10	0	1.95	1.28	1.12
Milk	–2.10*	0	5.29**	.28	1.48
Wool	–.91	–.168	.21	2.99*	1.05
Broilers	–2.20*	.181	.42	.01	1.08
Turkeys	–1.04	.111	.80	1.21	1.24
Eggs	–1.57	.017	.08	.37	1.29
Crops	–1.76+	–.023	.69	.63	2.61*
Livestock	–1.63	.037	.72	2.72+	1.29
All commod.	–2.03*	.011	.21	.07	1.05
Prices paid	–1.14	0	.10	.77	1.36

**,*, and + indicate statistical significance at the 1, 5, and 10 percent levels, respectively.
[1]Years are 1952-92 for citrus, 1955-93 for grapes, and 1957-93 for onions.

greater than average, and variabilities less than 13.55/1.39 = 9.75 are less than average. By this criterion, onions, rice, wool, oats, potatoes, grapefruit, oranges, corn, and gain sorghum exhibit significantly higher than average price variability while snap beans, tobacco, green peas, milk, broccoli, processing tomatoes, strawberries, and Choice steers exhibit significantly lower than average variability.

Conclusion

We have shown that agricultural commodities exhibit important and persistent differences in price variability. Variability has changed over time for certain commodities, most notably for the grains and soybeans, where prices were less variable during the fifties and sixties than in earlier or more recent decades. The persistence of commodity differences suggests that variability depends largely on inherent commodity characteristics, such as the elasticity of supply, production lags, yield variability, foreign production variability, storability, and elasticity of demand. Government policies and programs and other institutions appear to have moderated price variability in some cases. In particular, changes in U.S. and foreign policies on trade and exchange seem to account for some of the historical changes in grain and soybean price variability (See Miller, et al.). Government programs probably have reduced the variability of milk and tobacco prices while industry structure and marketing practices may account for the relatively low variability of processing vegetable prices. Detailed analyses of individual commodities is needed to assess the effects of specific programs and policies on price variability.

Finally, the longterm downward drift in real farm prices, while reflecting major gains to consumers, is grounds for continuing concern for persons and

firms in agriculture. The historical prices analyzed here tell us little about how long and at what rate these downward drifts will continue. To make such forecasts calls for studying prospective changes in demand, supply, and costs, for individual commodities.

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A Random Coefficient Meat Demand Model

William F. Hahn

Abstract. *The stability of the U.S. consumer demand for meat has been a popular topic for journal articles. I show that econometric models imply that demand is fundamentally unstable. A good way to build taste instability into econometric demand equations is to specify them as random coefficient models. I estimate a random coefficient model of meat demand and find significant evidence that taste instability has caused fluctuations in the elasticities of demand for beef, pork, chicken, and turkey.*

Keywords. *random coefficients, demand systems, meat demand, taste stability.*

The U.S. consumer demand for meat has been a popular topic for journal articles. For example, there were three articles on this topic in the May 1993 issue of the *American Journal of Agricultural Economics (AJAE)* alone (Alston and Chalfant (1993), Eales and Unnevehr, and Yong and Hayes). Much of the interest in meat demand has been driven by the controversy over the stability of consumer tastes for red meat. Beef consumption has dropped since the 1970's while poultry consumption has steadily risen. Some have attributed this drop in beef consumption to consumer health concerns while others have attributed it to the increase in beef prices relative to poultry prices. Each of the three articles just mentioned addressed the issue of the stability of consumer tastes for meats. Alston and Chalfant and Eales and Unnevehr concluded that the demand for meats has been stable while Yong and Hayes concluded that it has not.

I take the view that the U.S. demand for meat has been fundamentally unstable and estimate a random coefficient model of meat demand. In this, I am actually being consistent with Alston and Chalfant, Eales and Unnevehr, and Young and Hayes, even though only Yong and Hayes actually conclude that tastes have been unstable. The debate over the stability of meat demand is muddled by the fact that there are actually two different definitions of stability, although everyone seems to act as if there were only one. The first definition of stability requires stable consumer tastes. The second definition is that consumer demands can be represented using econometric demand functions with stable parameters. Alston and Chalfant and Eales and Unnevehr used the stable parameter definition of demand stability while Yong and Hayes used the stable taste definition. The random coefficient meat demand model is based on the stable (or at least stationary) parameter definition but implies unstable tastes. In fact, all econometric specifications of demand imply unstable tastes. Alston and Chafant and Eales and Unnevehr tested econometric models of meat demand and found that their models' parameters were stable. However, the random components of their models imply that tastes are unstable.

Given a set of tastes (meeting certain regularity conditions), there will exist a set of demand functions that relate what consumers want to buy to the prices of goods and total expenditure. Econometric demand functions depend on prices and expenditures, but have random components as well. The random components imply that demand reacts to factors other than prices and expenditure. In theory, the only other factors left to explain demand are tastes. Econometric specifications of demand functions imply that tastes are not stable.

It is not too hard to come up with reasons why tastes might fluctuate somewhat randomly. Tastes may be influenced by more or less random factors in the consumer's environment such as weather. There could be a stable demand relationship between prices, expenditures, and random "environmental" factors, a "meta-utility" relationship. The econometric demand specification could be random with stable parameters and consistent with utility maximization, but not consistent with stable tastes.

Data, Model Specification, and Estimation Procedure

This study uses monthly data from USDA-ERS on the U.S. disappearance of beef, pork, chicken, and turkey, the four major meats consumed within the United States. The quantities are the estimated, per-capita, monthly disappearances of beef, pork, chicken, and turkey. Beef and pork disappearances are measured on a retail weight basis, while chicken and turkey consumption is measured on the ready-to-cook basis. The beef price is the retail Choice beef price as reported in ERS price spreads and the pork price is also the retail price

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calculated for prices spreads. Chicken and turkey prices are national average prices for whole birds. The time period used consists of the years from 1980 to 1992 inclusive, 156 observations.

I have assumed that the demand for these four meats is weakly separable from the demands for other goods. This assumption allows one to model meat demand conditional only on meat prices and meat expenditures. The assumption of separability is common in the analysis of meat demand. Moschini, Mora, and Green (1994) have presented evidence that meat demand is separable from the demand for other goods.

The Demand System

I specified meat demand using Keller and Van Driel's CBS system. (CBS stands for the Central Bureau of Statistics of the Netherlands, then Keller and Van Driel's employer.) The CBS system has a number of advantages. The system is linear in its parameters, which greatly simplifies its estimation. The CBS system can be aggregated across consumers to a market level demand. The fixed coefficient CBS model can be seen as a special case of the random coefficient model, and this allows testing of the random coefficient version. It is possible to impose all the restrictions of demand theory on the coefficients.

The CBS model resembles the Rotterdam model. In their 1991b and 1993 papers, Alston and Chalfant found that U.S. meat demand estimated with the Rotterdam model had stable coefficients. Other researchers that have used the Rotterdam model for meat or food demand include Gao and Shonkwiler (1993) and Moschini, Mora, and Green.

The primary difference between the Rotterdam and CBS model is that the CBS model has non-linear Engle curves. The CBS's expenditure response is identical to that of Deaton and Muellbauer's Almost Ideal Demand System (AIDS) in that the budget shares are a function of the logarithm of expenditures. Deaton and Muellbauer noted that cross sectional studies of consumer purchases demonstrate that this type of expenditure response provides a superior fit.

Prior to the estimation of the random coefficient system, I compared the performance of the Rotterdam and CBS model by specifying a model that was a mixture of the CBS and Rotterdam models and estimating it using the meat data. (Alston and Chalfant made a similar comparison of the AIDS and Rotterdam model in their 1993 paper.) The model had a parameter that was 1 for the CBS specification, zero for the Rotterdam specification, and between zero and 1 for a mix of the two. The estimated coefficient was almost exactly 1 supporting the CBS mode. The calculated test statistic for this coefficient was not significantly different than 1 and significantly different from zero. However, the test statistic is based on the assumption that only the intercepts of the meat demand models are random, and the true distribution of the test may not conform to the hypothetical one.

Like the Rotterdam model, the CBS model is based on a set of partial differential equations. The CBS's partial differential equations can be written as:

$$W_i \left(\partial Ln(q_i) - \sum_j W_j \partial Ln(q_j)\right) = A_i + \sum_j C_{ij} \partial Ln(p_n) + B_i \left(\partial Ln(X) - \sum_j W_j \partial Ln(p_j)\right) \quad (1)$$

where p_i, q_i, and X are the price of the i'th good, the quantity demanded of the i'th good, and total expenditure. In the tables of this report where estimates are presented, those variables subscripted by b refer to beef, p is for pork, c is for chicken and t is for turkey. The term W_i is the budget share defined by the following equation:

$$W_i = \frac{p_i q_i}{X} . \quad (2)$$

The terms A_i, B_i, and C_{ij} are parameters of the model. Prices and expenditures affect demand through the B_i and C_{ij} coefficients. The A_i represent those changes in demand caused by changes in tastes. A positive value of A_i implies that the demand for good i will increase even if all prices and expenditures do not change.

The partial differential equation, (1), defines the CBS model. However, one does not observe the derivatives of the demand function. One observes prices, quantities, and expenditures. The CBS model, like the Rotterdam model, is estimated by using the differential equation as the basis for specifying a set of difference equations. Usually, these models are estimated in first difference form. However, the data used here is monthly data and there is considerable seasonality in the demands for meats. To correct for this seasonality, the model was estimated in twelfth differences. Data for one month were compared with those from a year earlier.

I also allow the model's parameters to vary randomly over time. The typical CBS formulation has fixed coefficients and an error term. The error term effectively makes the intercepts, the A_i,

random. In the typical CBS model, taste changes cause fluctuations in the level of demand. The Random Coefficient CBS, (RCCBS) used in this paper will have random B_i and C_{ij} as well. In the RCCBS taste changes will cause fluctuations in the elasticities of demand as well as in the level of demand.

The RCCBS's difference equations are specified:

$$y_{i,n} = A_{i,n} + \sum_j C_{ij,n}\Delta^{12}Ln(p_{j,n}) + B_{i,n}(\Delta^{12}Ln(X_n) - \Delta^{12}P_n) \quad (3)$$

Note that all the coefficients in the RCCBS have an additional subscript so that their values can vary over time period. The terms $A_{i,n}$, $B_{i,n}$, and $C_{ij,n}$ are the time varying values of A_i, B_i, and C_{ij}. The term P_n is a price index, and there is a quantity index Q_n in the formula for $y_{i,n}$. The terms not yet fully defined are generated using the following equations:

$$\Delta^{12}P_n = \sum_j W_{j,n-12}\,\Delta^{12}Ln(p_{j,n}), \quad (4)$$

$$\Delta^{12}Q_n = \sum_j \left(\frac{W_{j,n-12} + W_{j,n}}{2}\right) \Delta^{12}Ln(q_{j,n}), \quad (5)$$

$$y_{i,n} = \left(\frac{W_{i,n-12} + W_{i,n}}{2}\right) (\Delta^{12}Ln(q_{i,n}) - \Delta^{12}Q_n), \quad (6)$$

Note that (5) and (6) use the average of current and lagged budget shares, while (4) uses lagged budget shares only. The use of average budget shares should make the difference equation in (3) better approximate the differential equation, (1). However, the use of average budget shares introduces the possibility of simultaneity bias in making the price index P_n a function of current endogenous variables. As a compromise, the lagged budget shares appear on the right-hand side while average shares appear on the left.

The economic theory of consumer demand implies four sets of restrictions on consumer demand functions. Keller and Van Driel demonstrate how these restrictions can be applied to the CBS. Their results are extended to the RCCBS and summarized below.

Three of these sets are equality restrictions. One set of equality constraints is the adding-up or aggregation constraints. Consumer demand functions need to be constructed so the sum of the money spent all goods adds up to total expenditures. Adding-up implies the following restrictions on the demand system's parameters:

$$\sum_i A_{i,n} = 0, \forall\ n, \quad (7)$$

$$\sum_i B_{i,n} = 0, \forall\ n, \text{ and} \quad (8)$$

$$\sum_i C_{ij,n} = 0, \forall\ j,\ n. \quad (9)$$

As is the case with many demand systems, the adding up restrictions for the RCCBS model hold automatically. When the $y_{i,n}$ of the CBS are summed over all "i", that sum is zero. The adding-up constraints (7-9) cause the right-hand side of (3) to sum to zero when summed across meats.

Demand functions are also required to be homogeneous of degree 0 in prices and expenditures. This condition is met through the set of restrictions defined by:

$$\sum_j C_{ij,n} = 0, \forall\ i,\ n. \quad (10)$$

The last equality conditions are the symmetry conditions on the compensated demand derivatives. The symmetry conditions imply:

$$C_{ij,n} = C_{ji,n},\ \forall\ i, j, n. \quad (11)$$

Note that given the symmetry conditions, the restrictions implied by (9) and (10) are identical, so that one set of these equations becomes irrelevant.

The inequality restrictions come into play through the requirement that the matrix of compensated demands be negative semi-definite. Keller and Van Driel demonstrate that these sign conditions imply that each time period's matrix of $C_{ij,n}$ terms must be negative semi-definite. One implication of the inequality restrictions is that the $C_{ii,n}$ coefficients cannot be positive.

Stochastic Specification of the Random Coefficient Demand System

At this point, I am going to switch the notation that I use to specify the RCCBS. The RCCBS can be specified as a linear model with time-varying coefficients:

$$y_{i,n} = z_{i,n}\,\theta_n. \quad (12)$$

In (12) $z_{i,n}$ is an appropriately configured vector of price and expenditure terms, the predetermined variables of the model.

Equation (12) could be any model with coefficients that vary over time. I had to specify the process generating the coefficients prior to estimation. I

assumed that the coefficients are identically and independently distributed over time. I denote the expected value of θ_n by θ and the covariance matrix of the coefficients by Σ_θ. The expected values and variances of $A_{i,n}$, $B_{i,n}$, and $C_{ij,n}$ will be denoted by A_i, B_i, C_{ij}, σ_{Ai}, σ_{Bi}, σ_{Cij}.

The restrictions that apply to the time-varying coefficients also apply to their mean values. These restrictions also have implications for the covariance matrix, Σ_θ. While there are 24 total coefficients in the RCCBS for the four meats, the equality restrictions allows one to eliminate 12 of the coefficients from the model: one of the four $A_{i,n}$, one of the four $B_{i,n}$, and ten of the sixteen $C_{ij,n}$. Because of the equality restrictions, the covariance matrix, Σ_θ has a rank of 12 at most. If only the intercepts are random, the covariance matrix has a rank of 3. I have assumed that the A_i must be stochastic. If not, then if prices and expenditures do not change, demand changes will be perfectly predictable.

The Three-Stage Estimation Procedure

I estimated the model in three stages. I used the first two stages to estimate Σ_θ and the last to estimate θ. This type of model is difficult to estimate with standard econometric packages, so I estimated the model using the mathematical programming software, GAMS (Brooke, Kendrick, Meeraus, 1988).

Note that the random coefficient model specified in (12) can be rewritten as fixed coefficient model with heteroskedastic error terms as follows:

$$y_{i,n} = z_{i,n}\theta + e_{i,n}, \tag{13}$$

where

$$e_{i,n} = z_{i,n}(\theta_n - \theta), \tag{14}$$

and:

$$E(e_{i,n}e_{j,n}) = z_{i,n}\,\Sigma_\theta z_{j,n}' \tag{15}$$

When only the intercepts are random, the variances and covariance implied by (15) will be fixed over all observations. If other coefficients are random, the (co)variances will be functions of the prices and/or expenditures. Because of the adding up properties of the CBS model, the full covariance matrices of the $e_{i,n}$ terms is singular for both the RCCBS and the CBS.

For all three stages, I imposed the equality restrictions directly estimating only the 12 of the 24 elements of the θ vector. I also only directly estimated the parts of the Σ_θ associated with the 12 estimated coefficients.

In the first stage, I used the specification in (13) and estimated θ without correcting for the heteroskedasticity implied by random elasticities of demand. The estimated values of θ were those that minimized the determinant of a three-by-three sub-matrix of the $e_{i,n}$ covariance matrix. Barten (1969) has shown that using this procedure for demand systems that add up produces estimates that are independent of the excluded good. The excluded variable was turkey. The first stage estimates will produce consistent, though possibly inefficient, estimates of the mean parameter vector. Given the consistency of the θ estimate, I then have consistent estimates of the $e_{i,n}$. Call those estimates $\hat{e}_{i,n}$.

I used the error terms from the first stage to estimate the covariance matrix in the second stage. The second stage is the most important of the three, because as (13-15) show, the only difference between the RCCBS and CBS is that the RCCBS has heteroskedastic error terms.

I estimated Σ_θ by finding the estimate, call it s_θ, that minimized the following relative sum of squared errors (SSE):

$$SSE = \frac{\sum_i \sum_j \sum_n D_{ij}\left(\overline{e_{i,n}} \cdot \overline{e_{j,n}} - Z_{i,n}\, s_\theta\, Z_{j,n}'\right)^2}{SST}. \tag{16}$$

where:

$$SST = \sum_n \sum_i \sum_j D_{ij} \left(\hat{e}_{i,n}\hat{e}_{j,n} - \frac{\sum_n \hat{e}_{i,n}\hat{e}_{j,n}}{144} \right)^2. \tag{17}$$

In (16) and (17), D_{ij} is a dummy variable that allows each covariance term to be used only once. For instance, it is 1 when i is b and j is p and zero when i is p and j is b. The estimates of the Σ_θ matrix from the second stage will be consistent.

The objective in (16) is the equivalent of 1 minus the R square of the regression implied by (17). This objective lies between zero and 1. The more the heteroskedasticity, the lower the objective function. The objective in equation (16) could be used as a test statistic if one knew its distribution.

To evaluate this test statistic, I used a Monte Carlo technique. I used the estimates of θ and covariance matrix for homoskedastic errors from the first stage along with the data on the

predetermined variables to generate new observations of the $y_{i,n}$ that were homoskedastic. I then ran these new $y_{i,n}$ through the first two stages to evaluate the distribution of the objective of equation (17).

It was in the second stage that I ran into some anticipated and unanticipated problems. The anticipated problem was the need to force the estimate s_θ to be symmetric and positive definite. Left unrestricted, the estimated s_θ was not. This problem was easily handled by specifying the matrix s_θ as the product of a matrix, K, and its transpose:

$$s_\theta = K'K. \tag{18}$$

The unanticipated problem was that my first estimated K matrix had a rank of only 6. For the third stage of the estimation, it would have been helpful, but not necessary, for the s_θ to have its full rank of 12. To make the estimated matrix have its full rank, I resorted to a version of ridge regression. I restricted the K matrix to be a six by twelve matrix and then specified s_θ as follows:

$$s_\theta = K'K + rM. \tag{19}$$

where r is a small positive weight and M a positive, semi-definite matrix. The usual procedure in ridge regression is to specify M as the identity matrix or some other diagonal matrix. However, because of the equality constraints, the Σ_θ can not be a diagonal matrix. I used an M matrix that could be a Σ_θ, consequently, M was also consistent with the equality constraints. The M matrix is block diagonal in the A, B and C coefficients. Its values can be seen in table 1. The M matrix actually used in the program was taken from Table 1, but reduced to a 12 by 12 matrix. The value of r I used was 10^{-8}.

In stage 3, I estimated the mean value parameter. Swamy and Tinsley (1980) developed a procedure that is useful for estimating linear, random-coefficient regression models such as specified by

Table 1—The non-zero elements of the "M" matrix, times 3[1]

	A_b	A_p	A_c	A_t
A_b	3	–1	–1	–1
A_p	–1	3	–1	–1
A_c	–1	–1	3	–1
A_t	–1	–1	–1	3

	B_b	B_p	B_c	B_t
B_b	3	–1	–1	–1
B_p	–1	3	–1	–1
B_c	–1	–1	3	–1
B_t	–1	–1	–1	3

	C_{bb}	C_{bp}	C_{bc}	C_{bt}	C_{pp}	C_{pc}	C_{pt}	C_{cc}	C_{ct}	C_{tt}
C_{bb}	3	–1	–1	–1	–1	1	1	–1	1	–1
C_{bp}	–1	3	–1	–1	–1	–1	–1	1	1	1
C_{bc}	–1	–1	3	–1	1	–1	1	–1	–1	1
C_{bt}	–1	–1	–1	3	1	1	–1	1	–1	–1
C_{pp}	–1	–1	1	1	3	–1	–1	–1	1	–1
C_{pc}	1	–1	–1	1	–1	3	–1	–1	–1	1
C_{pt}	1	–1	1	–1	–1	–1	3	1	–1	–1
C_{cc}	–1	1	–1	1	–1	–1	1	3	–1	–1
C_{ct}	1	1	–1	–1	1	–1	–1	–1	3	–1
C_{tt}	–1	1	1	–1	–1	1	–1	–1	–1	3

[1]Symmetry conditions have been used to eliminate non-unique C_{ij}.

(12). They presented their technique for a single equation model, but the generalization to a system specified as in (12) is trivial. Their model also allows one to specify the error terms as an integrated autoregressive/moving average (ARIMA) process, so the RCCBS is a rather simple random coefficient model. Given an estimate of Σ_θ, which I had from the second step, their technique will produce estimates of the time path of θ_n and an estimate of the mean value of the coefficient vector, θ.

Basically, their procedure is to find estimates of θ_n and θ, call them T_n and T, that solve the following problem:

$$\textit{Minimize} \quad \sum_n (T_n - T)' \, s_\theta^{-1} \, (T_n - T) \tag{20}$$

$$\textit{subject to: } y_{i,n} = z_{i,n} \, T_n, \quad \forall \; i,n.$$

Up to this point I have not addressed the problem of insuring that the $C_{ij,n}$ estimates are negative definite. These inequality constraints can be imposed in general by adding a set of non-linear inequalities to the minimization problem in (20). A less complex method is to force all the off-diagonal $C_{ij,n}$ to be positive. Given the homogeneity and symmetry constraints, this simple sign constraint is enough to insure that all the $C_{ij,n}$ matrices are negative, semi-definite. The sign constraint also forces all the meats to be substitutes for one another, which is consistent with my prior expectations.

I tried the Swamy-Tinsley specification, but it did not converge even after 50,000 iterations. I therefore decided to use the specification implicit in equation (13) and estimate the value of θ using generalized least squares. I estimated the covariance matrix of the error terms using equation (15), replacing Σ_θ with its estimate, s_θ.

The GLS type specification does not allow me to directly estimate the time path of the random coefficients. However, the primary variables of interest are their means and covariance matrix. Also, as Swamy and Tinsley demonstrated, the estimated time path of the coefficients will not be accurate. They demonstrated that specification of the problem in (20) insures that the estimated time path of the coefficients will tend to be "smoother" than the actual, unobserved time path. Further, it is possible to show, that without the inequality restrictions imposed on the $C_{ij,n}$ estimates, the estimated mean vector for the GLS and for the Swamy-Tinsley procedures will be identical. See the appendix.

As noted above, because of the adding-up features of the CBS model, the error term covariance matrix for all four meats will be singular. To get estimates of the coefficients, I performed GLS on a three-meat group. The excluded meat was turkey.

Evaluating the Properties of the Estimates

The three-stage procedure will produce consistent estimates of Σ_θ and θ, given the usual conditions for consistency. However, an evaluation of the model requires estimates of the "accuracy" of the estimates in small samples. The three-stage procedure is nonlinear, and asymptotic approximations may be inaccurate given the sample size.

To estimate standard errors for the estimates, I used the nonparametric procedure called jackknifing. Efron and Gong (1983) discussed jackknifing in their review article. This procedure is straightforward. I created 144 alternative subsamples of the data by dropping a different observation from each. I ran the three-stage procedure on each of the subsamples, and used the s_θ and T from each subsample to calculate standard errors for the estimates using the full sample.

Following Efron and Gong, suppose that X is some statistic generated from a sample of size N and that $X_{(n)}$ is the same statistic generated from the sample with observation n dropped. The jackknife standard error of X, denoted s_x, is:

$$s_x = \left(\frac{N-1}{N} \sum_{n=1}^{N} \left(X_{(n)} - \frac{\sum_{n=1}^{n} X_{(n)}}{N} \right)^2 \right)^{1/2} \tag{21}$$

One of the interesting features of the jackknife and related nonparametric methods that Efron and Gong note is that they can give accurate estimates of the distribution of estimators even when the estimators come from misspecified models.

Results

The objective value from the second stage was 81.4 percent, and R squared of just under 19 percent. At first glance, this is not a great fit. However, I ran 200 Monte Carlo iterations of a homoskedastic model with the parameter and covariance matrix estimates from the first stage. The smallest objective from the Monte Carlo trials was 85.2 percent.

If 81.4 percent were in fact not significant at the 5 percent level, it would be extremely unlikely that none of the 200 iterations would come up with an objective value less than 81.4. Also, the estimated fifth percentile from the Monte Carlo trial is 89.1, and the jackknife standard error of the fifth percentile estimate is 0.03. The objective value

from the second stage is more than 200 standard deviations below the estimated fifth percentile, further proof that the objective is significant at the 5 percent level. Consequently, I reject the CBS model in favor of the RCCBS model. Fluctuations in tastes have caused fluctuations in the elasticities of demand for meats.

Table 2 has the estimates of the mean values of the parameters and estimates of the standard deviations of the random coefficients implied by the s_θ from the second stage along with the jackknife standard errors of the estimates. Table 3

Table 2—Selected parameter estimates and their jackknife standard errors

	Estimate of mean of coefficient (1)	Jackknife standard error estimate for mean (2)	Estimate divided by jackknife standard error (1)/(2)	Estimate of standard error of coefficient (3)	Jackknife standard error estimate for standard error (4)	Estimate divided by jackknife standard error (3)/(4)
A_b	−0.006	0.002	−2.775	0.004	0.002	1.704
A_p	−0.001	0.002	−0.477	0.005	0.002	2.589
A_c	0.005	0.001	5.703	0.005	0.001	6.929
A_t	0.002	0.001	3.093	0.003	0.001	3.186
B_b	0.053	0.038	1.381	0.154	0.036	4.232
B_p	−0.017	0.027	−0.612	0.108	0.033	3.282
B_c	−0.014	0.024	−0.579	0.068	0.015	4.541
B_t	−0.022	0.012	−1.841	0.024	0.015	1.593
C_{bb}	−0.154	0.025	−6.165	0.054	0.019	2.844
C_{bp}	0.114	0.021	5.407	0.078	0.022	3.498
C_{bc}	0.027	0.012	2.211	0.036	0.015	2.348
C_{bt}	0.013	0.014	0.922	0.049	0.011	4.500
C_{pp}	−0.123	0.024	−5.054	0.088	0.021	4.263
C_{pc}	0.001	0.009	0.061	0.022	0.007	3.201
C_{pt}	0.008	0.011	0.738	0.036	0.009	3.798
C_{cc}	−0.024	0.009	−2.683	0.025	0.007	3.432
C_{ct}	−0.003	0.008	−0.395	0.011	0.005	2.293
C_{tt}	−0.018	0.010	−1.751	0.022	0.007	3.043

Table 3—Conditional[1] elasticities (and standard errors) implied by mean coefficient estimates and mean budget shares

	Regular elasticities of demand				
	Beef price	Pork price	Chicken price	Turkey price	Meat expenditure
Beef quantity	−0.869 (0.264)	−0.095 (0.123)	−0.117 (0.043)	−0.020 (0.103)	1.101 (0.301)
Pork quantity	−0.090 (0.470)	−0.699 (0.224)	−0.143 (0.040)	−0.010 (0.128)	0.941 (0.396)
Chicken quantity	−0.298 (0.468)	−0.256 (0.075)	−0.299 (0.123)	−0.058 (0.049)	0.911 (0.433)
Turkey quantity	0.080 (1.511)	0.070 (0.651)	−0.147 (0.176)	−0.459 (0.548)	0.456 (0.832)
	Compensated elasticities of demand				
Beef quantity	−0.296 (0.120)	0.219 (0.158)	0.052 (0.072)	0.025 (0.094)	
Pork quantity	0.400 (0.289)	−0.431 (0.309)	0.002 (0.074)	0.029 (0.115)	
Chicken quantity	0.177 (0.246)	0.003 (0.137)	−0.159 (0.159)	−0.021 (0.051)	
Turkey quantity	0.317 (1.198)	0.199 (0.794)	−0.077 (0.189)	−0.440 (0.554)	

[1]Elasticities are conditional on a given level of meat expenditure.

shows the elasticities of demand implied by the mean coefficient estimates. Because the B_i and C_{ij} are random, these elasticities will vary randomly over time. Table 3 also shows the standard deviations of the elasticities of demand implied by s_θ estimates.

The estimated mean A_i values for beef, chicken, and turkey are statistically significant. The mean A_i measure the general drift in tastes over time. The estimated A_i for beef is negative, which suggests a general decline in beef demand over time, while the positive intercepts for the poultry meats suggests increases in poultry demand over the time period.

The B_i coefficients show an interesting pattern. None of the mean estimates is significant at conventional levels. When the B_i are zero for the CBS system, the implied expenditure elasticities are exactly 1. With the exception of turkey, the expenditure elasticities of demand implied by the mean coefficient values in table 4 are all close to one.

While the mean values of the B_i are relatively close to zero, the standard deviations of these random coefficients are among the largest of any of the random coefficients. The B_i for beef and pork have the two largest estimated standard deviations. These large standard deviations imply that the expenditure elasticities are particularly unstable over time.

The uncompensated demand elasticities are functions of the B_i and C_{ij}. The instability of the B_i also affects all the regular price elasticities. The instability of the B_i could be a sign that taste variations has a great impact on expenditure elasticities and, consequently, on the expenditure effects of price changes.

On the other hand, values of B_i other than zero imply non-linear Engle curves. As Deaton and Muellbauer noted in their article on the AIDS system (which has the same type of expenditure effects as the CBS system), consumer demand systems with this type of nonlinear Engle curve require nonlinear aggregation to market level demands. Some of the instability of the B_i could be the result of aggregation problems in estimating changes in meat expenditures over time.

I made no effort to constrain the estimated mean C_{ij} coefficients to meet the inequality restrictions of demand theory. As it turned out, the mean estimates meet the restrictions without constraints. The coefficient of the cross price effects between chicken and turkey is negative, though small in absolute value and not significant. The sign implies that chicken and turkey are on average complements. This coefficient also has a large standard deviation relative to the mean value of the coefficient, suggesting that the chicken/turkey cross price effect is not stable and these two could be substitutes for much of the time period. Other goods are on average substitutes with one another. Beef and pork have the largest cross price coefficient. This coefficient and the elasticity estimates in table 4 suggest that beef and pork are (on average) better substitutes with one another than any other pair of meats.

Summary and Conclusions

Previous work (Chalfant and Alston, 1988, Alston and Chalfant, 1991a) has shown that it is possible to test for the stability of consumer tastes. However, econometric models of demand are implicitly based on the assumption that consumer tastes fluctuate randomly. Consequently, evidence that tastes are not stable does not rule out the possibility that econometric models are appropriate.

I have estimated a random coefficient model for this paper, using U.S. meat demand data for the 1980's and early 1990's. The one disadvantage of the random coefficient approach is that it is quite computer-intensive. Rather than specify the model as a "classic" random coefficient model, I ended up specifying it as a problem in generalized least squares. This approach limits the choices of stochastic specification for the model. In theory, one can specify random coefficient models with rather complex autocorrelation processes generating the coefficients. However, even with the use of high quality hardware and software, I was unable to get a "classic" random coefficient model without autocorrelation to converge. Future improvements in computational technology may solve some of these problems.

Technical problems aside, there are real advantages to using the random coefficient model in this instance. Hypothesis tests demonstrate that a general, random coefficient specification is superior to the more typical specification for modeling U.S. meat demand. The random coefficient specification implies that meat demand elasticities have fluctuated over the sample period because of fluctuations in consumer tastes.

The results also show that the general trend in consumer tastes had tended to favor poultry demand over beef demand. Pork demand appears to be relatively stable. The estimates support the views of those that believe that shifts in consumer

tastes have hurt the demand for beef relative to the demand for poultry.

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Appendix: Proving the Equivalence of the Swamy-Tinsley and GLS Estimates of the RCCBS

The first step in this proof is setting up (16) as a Lagrangian:

$$\text{Minimize} \quad \sum_n (T_n - T)' \, s_\theta^{-1} \, (T_n - T) + 2(Y_n - Z_n T_n)' \, \lambda_n. \tag{22}$$

In (23), the term Y_n is three by 1 vector consisting of three of the four $y_{i,n}$ terms (the fourth is irrelevant because of adding up) and Z_n a stacked matrix of the $z_{i,n}$ vectors. Taking the first derivative with respect to T_n gives:

$$2s_\theta^{-1} \, (T_n - T) - 2Z_n' \, \lambda_n = 0. \tag{23}$$

which gives the following solution for T_n:

$$T_n = T + s_\theta \, Z_n' \lambda_n. \tag{24}$$

Now, take the derivative with respect to the multiplier, substituting (25) for T_n:

$$2(Y_n - Z_n \, (T + s_\theta \, Z_n' \lambda_n)) = 0, \rightarrow$$

$$\lambda_n = (Z_n s_\theta Z_n')^{-1} \, (Y_n - Z_n \, T) \tag{25}$$

Note that the term $(Z_n s_\theta Z_n')$ in (26) is the convariance matrix for the heteroskedastic error terms. Equation (26) can be substituted into (25) to give the following solution for T_n:

$$T_n = T + Z_n \, (Z_n s_\theta Z_n')^{-1} \, (Y_n - Z_n \, T) \tag{26}$$

Now, take the derivative of (23) with respect to T:

$$-2 \sum_n s_\theta^{-1} \, (T_n - T) = 0, \tag{27}$$

and substitute (27) for T_n and solving for T gives:

$$T = \left(\sum_n Z_n' (Z_n s_\theta Z_n')^{-1} Z_n\right)^{-1}$$

$$\left(\sum_n Z_n' (Z_n s_\theta Z_n')^{-1} Y_n\right) , \qquad (28)$$

which is the GLS estimator of T.

Stock Price Reaction to Regulation in the Meat Packing Industry

Mark S. Johnson, Ron C. Mittelhammer, and Don P. Blayney

Abstract. *The results of this study suggest that a variety of regulations in the meat packing industry had significant, and sometimes unexpected, effects. The specific results of regulatory event testing show that many regulatory changes produce large significant impacts on the meat processing industry, in this study shown to be as large as 4% of shareholder wealth for a single informational event. The effects of each specific regulatory change on shareholders is dependent upon the type of regulation examined. These large impacts on the wealth of shareholders indicate that regulatory agencies and the regulations they create often serve the industry, as well as consumers. Finally, in this paper a refined Capital Asset Pricing Model (CAPM) analysis that adjusts for an errors-in-variables problem arising due to nonsynchronous trading is utilized which may be useful in future event studies relating to the agricultural sector.*

Keywords. *stock price, event study, regulation, meat packing.*

Cash receipts from farming in the United States totaled $179,285 million in 1990. Meat animals were the largest category of receipts, accounting for approximately 29 percent of the total, with poultry and eggs accounting for another 8.5 percent (Agricultural Outlook). Situated between the producers of meat animals and poultry and the consumers of meat and poultry products is a well-developed meat packing and processing industry. This study examines the impacts of selected regulations and agricultural policies on that industry.

Researchers, policy makers and consumers should be concerned about the effects of agricultural policy and regulations on processing firms. In particular, the financial well-being of the industry can have important consequences for the future level of processing capacity and the prices of retail meat products.

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Until recently, the measurement of the impact of changes in government policies and regulations on sectors of the agribusiness sector has not explicitly utilized financial market data. This study utilizes common stock prices in the context of an event study to measure the effects of regulation on the meat packing industry. This approach, widely used by corporate finance researchers, is generally accepted as a valid approach for measuring the impact of events on the value of firms whose stocks are publicly traded on efficient financial markets. Events, in general, are defined as any changes in the economic environment which may affect the firm's value through changes in investor expectations about future risk and cash flows.

Previous event studies have examined a wide range of economic changes. The majority of published studies focus on the impact of firm-specific events such as mergers and acquisitions and issuances of debt and equity. However, several researchers have used the event study method to examine events that are not firm specific. Examples include the impact of government pronouncements on futures prices (Schroeder, Blair and Mintert) and the impact of regulatory changes on firm value. Studies of regulations include analysis of: OSHA-imposed dust standards on textile firms (Hughes, Magat and Ricks), the impact of product recalls (Jarrell and Peshman), the effects of the Bank Holding Company Act of 1970 (Aharony and Swary), deposit ceilings (Dann and James), merger regulations (Schipper and Thompson), tobacco industry regulations (Johnson, Mittelhammer and Blayney 1991) and pesticide industry regulations (Johnson, Mittelhammer and Blayney 1992).

There are at least three major reasons for measuring the impact of regulatory events on the value of meat packing firm equity. First, such measurement provides a quantification of the effect of regulation on shareholder wealth in terms of returns on investment. Secondly, resource reallocation into or out of the meat packing industry may be induced by regulatory impacts on firm value. Such resource reallocation could affect future processing capacity, prices received by farmers, and ultimately the cost of meat to consumers. Reallocation of resources away from the firm occurs when capital budgeting is done to evaluate potential investments in new projects and events cause the net present value of such projects

to be reduced. When these effects are industry-wide, capital will be allocated out of the industry. Third, evidence obtained in this study may be useful in understanding the relationship between regulations and the regulated in other agricultural subsectors.

During the last 30 years, many events occurred that could have significant impacts on the value of meat packing firms. These events included, but are not limited to, import restrictions, health requirements, and grading changes. This study focuses on events which occurred during the 1960-90 period which were anticipated, *a priori,* to have a significant impact on the supply of meat to processors and/or the cost of meat packing. Eleven events were chosen for this study. Selection of the events was based on personal communications with livestock researchers and analysts in the U.S. Department of Agriculture, a review of livestock and meat marketing literature, and a review of agricultural legislation (McCoy and Sarhan, Hayenga et al., Packers and Stockyards Administration, and Lasley and Henson).

Five of the events are regulations that directly impact the beef and pork processing industries. These include: the Meat Import Bill of 1964, the Revision of the Meat Import Bill in 1979, the Fair Packaging and Labeling Act of 1966, the Federal Meat Inspection Act of 1967, and the Humane Slaughter Act of 1978. Three of the events are regulations that directly impact the broiler and turkey processing industries. These events are: the Poultry Products Inspection Act of 1968, the Amendment to the Poultry Products Inspection Act in 1982, and the Poultry Producers Financial Protection Act of 1987. One event selected directly impacts the entire industry: the creation of the Office of Occupational and Safety and Health Administration (OSHA).

The final two events examined in this study, the Dairy Tobacco Adjustment Act of 1983 and the Food Security Act of 1985, were chosen because it was believed they might potentially influence the supply of meat to processors to such an extent that input prices of the raw commodity would be changed. The acts had an impact on the beef supply to processors through programs designed to reduce milk production in the United States by sending greater numbers of dairy cattle to slaughter. Such increased supply of cattle for slaughter, and the subsequent impact on the meat packing industry, would be a secondary effect of these government policies.

The remainder of the paper is presented in four sections. Section two describes the central tenet of the event study, the efficient market hypothesis. Section three describes the modified Capital Asset Pricing Model (CAPM) methodology used in this study. Section four provides an examination of the events and their impacts. Finally, a summary and conclusions are provided.

The Efficient Market Hypothesis and Event Measurement

The event study approach assumes that the efficient market hypothesis (EMH) is descriptively valid for markets in which a firm's stock is traded. The EMH implies that stock prices will reflect all available information that influences the firm's risk and expected future cash flows. The firm's stock price, and thus the value of its equity as perceived by analysts and investors, is the discounted value of future cash flows. The discount rate is determined by the perceived riskiness of the firm. Therefore, changes in stock prices, and thus firm value, reflect changes in expectations about future cash flows and risk. Because investors and analysts continually re-evaluate firm values, new information is quickly incorporated into stock prices.

A question that has been examined closely in the corporate finance literature is: "What information is quickly incorporated into stock prices?" At this point, most research indicates that stock markets in the United States are semi-strong efficient (Weston and Copeland). Such markets quickly reflect all publicly available information. Therefore, it would be expected that any publicly available information about regulation will be quickly incorporated into stock prices if the information changes investors' expectations regarding risk or future expected cash flows. Based on this observation, the event study approach focuses upon stock price changes at and around the time period information is released to the public, defined as the "event period." It is crucial to any event study that the time at which information is released to the public be identified as clearly possible.

Pinpointing the times when information is released to the public is particularly difficult when examining the effects of regulation. There are two major reasons for this difficulty. First, regulatory agencies often make multiple public announcements about possible regulatory changes prior to a final decision regarding the changes. Second, information occasionally leaks to the public from inside the regulatory agencies prior to official announcements. A detailed discussion of the rationale for the event period choices in this study is presented

in a subsequent section entitled "Analysis of Events."

Binder points out an additional aspect that is crucial to any event study: the determination of the effect which new information has on investor expectations. Investors expect a "normal" rate of return from holding a stock. These normal returns, in the form of dividends and capital gains, depend on the state of the macro-economy, the overall performance of the stock market and the perceived risk of the firm. Thus, when examining the impact of regulation on firm value, it is inappropriate to simply calculate the market value of the firm's equity before and after the regulatory event and attribute all of the change in value to the regulatory event. The impact of a regulatory event on the firm's value should be measured as the total change in returns at the time of the event minus the returns attributable to general market movement. The remaining effect is referred to as an abnormal return. The procedure used to identify abnormal returns is detailed in the following section.

The Model and Data

Three methodologies have been used to analyze abnormal returns; the mean-adjusted approach, the market-adjusted approach, and the risk adjusted capital asset pricing model (CAPM). The CAPM is used in this study for two reasons. First, simulation results have indicated that the power of test statistics associated with the mean adjusted method is low under conditions of clustering (Brown and Warner 1980, 1985). Clustering is a condition where firms in the sample are from the same industry, as is the case in the current study. Second, the CAPM is theoretically more appealing because it does not assume that the comovement of each firm's returns with the market is exactly one for one and that all firms' normal returns are the same on any given day. The market-adjusted approach does not allow the normal return level to vary when an asset's market risk changes. This may be seen by the fact that in the market-adjusted approach all firms are assumed to have the market return as the normal rate of return on any given day. Thus, the abnormal rate of return is assumed to be the same for all firms, and no adjustment is made for the specific riskiness of an individual firm.

In the CAPM, normal returns for each firm are determined by the comovement of a firm's returns with the market rate of return. Normal returns are the returns associated with the component of the firm's risk that cannot be diversified away by holding a diversified portfolio of stocks in the marketplace. "Abnormal" returns are the returns which can be attributed to the event being examined. As such, abnormal returns are obtained by subtracting normal returns from the actual returns for a firm observed in the market.

Use of the CAPM requires estimating a normal return generating equation for each firm from a pre-event period. In its simplest form, the relationship may be specified as in equation 1 and estimated via ordinary least squares (OLS).

$$R_{it} = \alpha_i + \beta_i R_{mt} + e_{it}, \tag{1}$$

where R_{it} is the actual return for firm i on day t, R_{mt} is the actual market return on day t, and e_{it} is a random error term. The value, $\alpha_i + \beta_i R_{mt}$, represents the normal return for firm i on day t attributable to general market movements.

Following the convention of previous studies and the findings of Brown and Warner (1980, 1985), an equal-weighted index is used as a proxy for the market rate of return in (1). The market index is calculated using all firms on the New York Stock Exchange (NYSE), approximately 1,500 firms, and refers to a portfolio where one share of common stock is held for each firm on the exchange. Even though many stocks are traded on other exchanges (e.g., AMEX, NASDAQ), the equal-weighted index is likely to be a good proxy because of its large number of firms and the diversity of firms in the portfolio. The return on the market index of all firms on the NYSE on day t is calculated as

$$R_{mt} = \frac{\sum_{i=1}^{1500} P_{it} - \sum_{i=1}^{1500} P_{it-1} + \sum_{i=1}^{1500} D_{it}}{\sum_{i=1}^{1500} P_{it-1}}, \tag{2}$$

where P_{it} equals firm i's price on day t and D_{it} is any dividend payment on day t.

The actual return for firm i on day t is calculated as the change in the firm's price from day t-1 to day t plus any dividends distributed on day t, all scaled by price on day t-1

$$R_{it} = \frac{P_{it} - P_{it-1} + D_{it}}{P_{it-1}}, \tag{3}$$

where P_{it} is the price of firm i's stock on day t, and D_{it} is the dividend for firm i on day t.

In contrast to most regulatory event studies, which examine the impact of regulation on large firms

(e.g., Johnson, Mittelhammer and Blayney 1991), the firms in the meat packing industry vary widely with respect to their equities market value, from amongst the smallest public firms to amongst the largest public firms in the U.S. Hence, some of the firms in the sample have actively traded stock while others have stock which may be traded sporadically, perhaps not even being traded each and every day the stock markets are open. This creates a potential serious econometric problem when using daily stock price returns to estimate equation 1. Scholes and Williams suggest that an errors-in-variables problem exists because of this "nonsynchronous" trading.

The model previously described assumes that daily stock price returns are computed using closing prices for each stock. Therefore, it is assumed that all returns reflect investor returns of holding the asset for a one day holding period while the market is open. The last trade of the day for a specific firm's stock may occur hours before the close of the market and be reported as the closing price, or the reported closing price may even be from a previous trading day if no trades have occurred. At other times, the reported closing price may reflect a transaction which occurred moments before the close of the market. Thus, the calculated daily return may not reflect the true return for an investor who holds the security for one trading day; and observations on R_{it} and R_{mt} may not be synchronized.

Few, if any, securities in the meat packing industry are so actively traded that prices are recorded continuously. The problem is likely to be more extreme the smaller the firm being examined. Given that prices are available only at distinct random intervals, "completely accurate calculation of returns over any fixed sequence of periods is virtually impossible" (Scholes and Williams). Scholes and Williams suggest an instrumental variable approach for estimation of the return generating process to solve this problem, where the instrument is an equally weighted moving average of the market rate of return. We follow this approach for estimating equation 1 where the specific instrument suggested by Scholes and Williams is given in equation 4, below.

$$MAM_t = \frac{R_{mt-1} + R_{mt} + R_{mt+1}}{3}, \qquad (4)$$

where MAM_t is a moving average of the market rate of return, and R_{mt-1}, R_{mt} and R_{mt+1} are defined as the equal weighted market return on days t-1, t, and t+1, respectively.

For most events in our study, the return-generating model was estimated for each firm using 60 days of data prior to the event. The 60-day period was chosen because it allowed most of the models to be estimated without contamination from prior events. The presence of a prior event in the estimation period can result in biased estimates of returns-generating models if the prior event produced abnormal returns which are large in absolute value.

When 60 days of daily data were not available between event periods, two alternatives for selecting the pre-event period were employed: 1) if at least 45 days of return data were available, the model was estimated based upon the maximum number of returns available between the event periods; or 2) if less than 45 days of return data was available, then the period prior to the contaminating event was utilized for model estimation. It was felt that these rules provided a reasonable trade-off between having sufficient observations to accurately estimate the returns model and the need for model estimation to be base on data reasonably close to the time of the event.

The estimated abnormal return, or equivalently the return associated with the event that cannot be explained by the normal return generating process, is specified in equation 5 for firm i on day t.

$$AR_{it} = R_{it} - [\hat{\alpha}_i + \hat{\beta}_i R_{mt}] \qquad (5)$$

The abnormal return is the actual return minus the return predicted from the normal return-generating equation.

Abnormal returns are commonly examined not only on the day of the event but also before and after the event to account for possible information leakage or late arrival of information to the market. A 3-day event window, spanning the day of the event plus the trading days before and after the event, is used in this analysis. An event window is the time period over which the impact of the informational event is examined. Information leakage to the market could occur if some market participants are privy to discussions among policy makers prior to public announcements of policy actions. Late arrival of information could also occur. For example, public announcements made at or near the end of the trading day for the stock exchange would not generate market reactions until the next trading day. For announcements that did not occur on a trading day, the day after

the announcement was used as if it were the announcement day because it was the first opportunity the market participants would have to react. Therefore, the 3-day abnormal return can be computed as in equation 6:

$$TAR_{it} = \sum_{t=t-1}^{t+1} AR_{it}, \tag{6}$$

where TAR_{it} is the 3-day abnormal return for firm i for event day t. TAR_{it} is then used to determine the impact of an event on firm i.

To determine the overall impact of the event on the industry, we calculate the 3-day average abnormal return by summing across the N firms in the industry as in equation 7:

$$TAAR_t = \sum_{i=1}^{N} \frac{TAR_{it}}{N}, \tag{7}$$

where $TAAR_t$ is the 3-day average abnormal return for the industry for event day t.

To examine whether the event had a significant value impact upon the industry, a test of the null hypothesis that the 3-day average abnormal return across firms equals zero is performed using the test statistic as suggested by Brown and Warner (1980):

$$t = \frac{TAAR_t}{\sqrt{3\hat{\sigma}^2}}, \tag{8}$$

where $\hat{\sigma}^2$ is the estimated average daily abnormal return variance over the estimation period. Letting t = 1 represent the day of the event, the variance is calculated as in equation 9:

$$\hat{\sigma}^2 = \frac{\sum_{t=-e}^{t=-1}\left(\frac{1}{N}\left(\sum_{i=1}^{N} AR_{it} - \sum_{t=-e}^{t=-1}\sum_{i=1}^{N}\frac{AR_{it}}{e}\right)\right)^2}{e-1}, \tag{9}$$

where e designates the first day of the estimation period. Thus, the variance of the average abnormal return in the pre-event period is being used in the test of the null hypothesis that the mean industry effect is zero.

Daily stock returns were obtained from the CRSP (University of Chicago Center for Research in Security Prices) data base for the twenty three meat processing firms listed in table 1. The firms listed in table 1 consist of all firms listed under the standard industrial code for meat packers and processors which, as best as we can determine, are actively involved in some level of meat animal slaughtering for which sufficient return data was available from CRSP. Firms that are not known to be engaged in slaughtering activities were excluded from the sample to be utilized because of potential problems that arise if such firms are included. Specifically, firms not engaged in slaughtering activities should be excluded because most of the regulatory events to be examined only impact firms that slaughter animals. Otherwise, noise introduced by inclusion of firms not effected by regulations impacting slaughter operations may obscure the significance of a regulatory event that only impacts slaughter firms. A firm is utilized in the analysis of a specific informational event if the informational event date is included in the time interval listed in the right-hand column of table 1, i.e., if the requisite returns data is available for both the event period and the estimation period.

Table 1—List of firms in the sample during selected time periods

Firm	Firm Name	Period for which Data is Available from CRSP[a]
1.	Armour & Co.	2/4/64 – 12/16/70
2.	Cudahay Co.	2/4/64 – 12/16/70
3.	Wilson & Co. Inc.	2/4/64 – 10/19/66
		11/28/67 – 11/28/67
		6/13/68 – 11/10/87
4.	Morrell, John & Co. Inc.	2/4/64 – 7/23/67
5.	Swift & Co.	2/4/64 – 11/23/83
6.	Sara Lee Corp.	2/4/64 – 11/10/87
7.	Hormel, George A., & Co.	2/4/64 – 11/10/87
8.	Hygrade Food Products Corp.	2/4/64 – 12/16/70
9.	Rath Packing Co.	2/4/64 – 12/31/79
10.	Chiquita Brands International Inc.	2/4/64 – 11/10/87
11.	Kane Miller Corp.	5/25/66 – 11/23/83
12.	Tobin Packing Inc.	5/25/66 – 6/6/79
13.	Iowa Beef Processors Inc.	7/9/70 – 12/31/79
14.	Missouri Beef Packers Inc.	7/9/70 – 9/28/78
15.	Oscar Mayer & Co. Inc.	7/10/78 – 12/31/79
16.	Cagles Inc.	7/10/78 – 11/10/87
17.	Buring Food Group Inc.	7/10/78 – 9/28/78
18.	Bob Evans Farms Inc.	7/10/78 – 11/10/87
19.	Dinner Bell Foods Inc.	7/10/78 – 11/10/87
20.	Thorn Apple Valley Inc.	7/10/78 – 11/10/87
21.	Imark Industries Inc.	7/10/78 – 11/10/87
22.	Smithfield Foods Inc.	7/10/78 – 11/10/87
23.	Kaplan Industries	6/24/82 – 11/10/87

[a]If an informational event occurs within the specified period then sufficient data was available to establish the event window and estimate the model.

Analysis of Events

From the large number of regulatory changes that occurred during the last 30 years it is difficult to determine *a priori* which regulatory changes are likely to have had a significant impact on the financial condition of meat packers. As indicated previously, a cross-section of 11 regulations affecting the meat packing industry is examined. A list of the regulatory events appears in chronological order in table 2. After identifying the regulatory events, it is necessary to then determine when information regarding the changes is likely to arrive in the market.

Regulations during the period examined were usually motivated by one of two basic concerns. First, import regulations and supply control, of either the meat industry or of interrelated industries, was primarily motivated by a desire to support the incomes of farmers. Second, other regulations were usually motivated by a concern for the quality of meat being purchased by consumers.

Five of the events, 1, 7, 9, 10, and 11, are regulatory events that were motivated by a concern over the level of farm incomes. Specifically, events 1 and 7 focused upon beef producer prices and incomes through import supply control, events 9 and 10 were aimed at supporting dairy product producer incomes through reduction in dairy product output (partially through reducing the size of dairy herds), and event 11 was focused upon the financial security of poultry producers. *A priori*, events 1 and 7 would be anticipated to affect meat processors directly through increased input prices. Events 9 and 10 would be anticipated to affect meat processors indirectly through a potential increase in the supply of meat from the culling of dairy cattle. Finally, event 11 may indirectly affect processors by potentially increasing the financial security of poultry producers and thus affect the cost of poultry to processors.

Four of the events, 2, 3, 4 and 8, are regulatory events which were motivated by a concern from policy makers that consumers should be assured of having safe meat products of known quality. These regulations could potentially affect meat processors in two ways. First, such regulations are likely to increase the costs associated with packaging, labeling and inspecting meat products. Increased production costs may have a negative profit effect on the industry. Secondly, these regulations may positively impact profits of the industry by increasing the demand for meat products. This increased demand may occur because consumers believe that they are increasingly assured of receiving safe,

Table 2—Potentially significant regulatory events affecting the meat packing industry

Event No.	Date	Event
1A	2/4/64	Introduction of a bill that would restrict meat imports below present levels.
1B	7/28/64	Passage of the Meat Import Bill by Congress.
2A	5/25/66	Introduction of a bill that would change labeling requirements and increase packaging standards.
2B	10/19/66	Passage of the Fair Packaging and Labeling Act.
3A	9/21/67	Introduction of a bill that would require indiviudal states to have an inspection program in place, for all meat products other than poultry, matching federal guidelines.
3B	11/28/67	Passage of the Federal Meat Inspection Act.
4A	7/23/67	Introduction of a bill that would require individual states to have an inspection program in place, for poultry, matching federal guidelines.
4B	6/13/68	Passage of the Poultry Products Inspection Act.
5A	7/9/70	Introduction of a bill which would create OSHA and give the occupational safety and health administration the obligation to oversee worker health and safety concerns.
5B	12/16/70	Passage of the bill creating OSHA.
6A	7/10/78	Introduction of a bill which would impose rules that ensure that animals are slaughtered in a humane fashion.
6B	9/28/78	Passage of the Humane Slaughter Act.
7A	6/6/79	Introduction of a bill that would amend the 1964 meat import law by adding a countercyclical component to the calculation of trigger levels that "turn on" or "turn off" quota restrictions.
7B	11/18/79	Passage of the Meat Import Act.
8A	9/9/81	Introduction of a bill that would amend the poultry production inspection act by changing the number of turkeys which may be slaughtered and processed without inspection under the 1968 act.
8B	6/24/82	Passage of the 1982 Poultry Products Inspection Act Amendment.
9A	6/22/83	Introduction of the Dairy Tobacco Adjustment Act which included a paid diversion program which could be accomplished by limited culling of dairy cows by farmers. This act potentially increased the supply of meat for slaughter.
9B	7/19/83	Passage of the Dairy Tobacco Adjustment Act.
10A	4/17/85	Introduction of the Food Security Act which authorized the whole herd buyout program. This act essentially increased the supply of meat for slaughter.
10B	7/31/85	Passage of the Food Security Act.
11A	10/8/87	Introduction of the Poultry Producers Financial Protection Act which would provide financial protection to poultry growers and sellers, and clarifies federal jurisdiction under the act.
11B	11/10/87	Passage of the Poultry Producers Financial Protection Act.

high quality products. Additionally, increased inspection by the entire industry may provide important reductions in liability or improve the ability of individual processors to compete in the marketplace. Thus, the net impact of such regulation is uncertain.

The remaining two events, 5 and 6, were motivated by a desire to protect industrial workers from unsafe practices and a desire to treat animals in humane fashion, respectively. These two events are examined because of their potentially large long-term impacts on the meat processing industry. These impacts may occur because rules can increase the labor cost of processing animals and increase the processing time required on a per-pound basis.

Choosing the announcements that provided the greatest possible information about regulation that occurred during the 1960-90 period was relatively straightforward. All of the regulatory events examined in this study are associated with bills passed by Congress and signed into law by the President. Two of the relevant regulations were contained in the 1983 and 1985 Farm Bills. The remaining regulations were established under separate bills. For all events, the first introduction of the bill into either the House of Representatives or the Senate and its passage by the originating body were the announcements examined. The original introduction was selected as an informational event because it provides the market with its first glimpse of changes generated by the political process that are likely to befall the industry. Passage of bills of this nature by the originating body are very rarely vetoed by the President, and thus passage of the bill signifies with " almost certainty" that there will be a regulatory change.

The introduction-passage process may be complicated, from the standpoint of investors and their formation of expectations, through leakage of information or firm-specific events, such as mergers, earnings announcements, and dividend announcements which may occur during the event window being examined. Firm-specific events could confound results of the study by causing stock price reactions that are not associated at all with the regulation being investigated. Therefore, the *Wall Street Journal index (WSJ)* was carefully examined in an attempt to detect either early release of information or confounding events. This exercise yielded no evidence of the early release of information prior to introduction of a bill or of the existence of confounding events during the event windows.

In addition to listing the regulatory actions examined, table 2 shows the dates of introduction and passage of the relevant legislation associated with the regulation. For example, event 1, the meat import bill of 1964, has two informational events associated with it: informational event 1A, introduction of the legislation, and informational event 1B, passage of the relevant legislation. In considering the results of analyzing the informational events it is important to consider not only the sign and significance of individual informational events, but also the overall pattern of effects. This holistic approach to the examination of results, as shown in table 3, is important because the regulatory environment is such that investors' expectations may be formed cumulatively on the basis of more than one informational event. This is especially true with legislative actions where the final bill may be revised before passage.

The events that produced significant abnormal returns (AR's) may be grouped into three categories: 1) regulatory events aimed at assuring consumers that meat products are safe and of high quality, which directly effect processors through inspection costs or changes in consumer demand due to changes in the perceptions of consumers regarding the quality of products provided by the industry; 2) regulatory events directly impacting the manner in which animals are slaughtered,

Table 3—Three-day mean abnormal returns associated with events affecting firms known to be engaged in slaughter activities

Event No.	TAAR	t-statistic	No. of Firms with available data
1A	-1.0735	-.9365	10
1B	-.1877	-.1899	10
2A	1.7069	1.3652	12
2B	3.4336	3.8941*	12
3A	-.8052	-.4551	10
3B	1.1853	.9343	11
4A	4.2491	2.9962*	11
4B	-.2218	-.1451	11
5A	-.7466	-.4916	12
5B	1.4385	.9243	12
6A	-2.1358	-2.4412*	19
6B	-2.9093	-2.7635*	19
7A	1.5465	1.3658	16
7B	.6752	.5810	15
8A	1.5206	1.2421	12
8B	.5856	.5588	13
9A	1.4491	1.0922	13
9B	.8716	.7003	13
10A	-.0120	-.0094	11
10B	1.5033	1.1828	11
11A	-.3019	-.2551	11
11B	-3.8190	-2.8091*	11

*Significant at .05

thereby directly effecting production costs; and 3) regulation that directly impacts the stability and profitability of poultry processors through farm level financial support to producers.

Informational events 2B and 4A are associated with new regulatory actions that are later modified. These actions increase the quality and safety assurance to consumers of beef and pork, 2B, and poultry products, 4A. Informational event 2B is the passage of the fair labeling and packaging standards. The impact of stricter labeling and packaging requirements, event 2, theoretically could be negative, positive, or produce no impact on the value of processing firms. While such a regulation imposes higher processing costs, it also may increase demand for meat products because of safety and quality assurance perceived by consumers. The combined effect appears as a positive 3.45% increase in shareholder wealth in the industry, as shown by the significance of informational event 2B, passage of the Fair Packaging and Labeling Act. This result suggests that when all processors bear similar additional costs, increased inspection can actually benefit the industry.

Informational event 4A is the introduction of the Poultry Products Inspection Act. The introduction of the Poultry Inspection Act, produced a positive 4.25% abnormal return. This positive impact may have been caused by one of two factors. First, the creation and enforcement of federal standards for the processing of poultry may have implied a reduction in poultry supply and/or the imposition of significant additional processing costs to poultry processors. Given that many consumers view pork and beef products as close substitutes, this Act may have improved the competitive position of the beef and pork processing firms in our sample relative to the position of poultry processors. Since the majority of firms in the sample are beef and pork processors this could explain the AR effect. Secondly, if consumers concluded that regulators were being diligent in their regulation of the entire meat industry, the imposition of new federal quality standards for poultry may have positively impacted the entire meat industry.

Category 2, regulations that could directly effect the cost and method of slaughter was found to have a large negative impact on the industry. Events 6A and 6B represent the introduction and passage of the humane slaughter bill. Both informational events produced significant negative AR's, –2.14 percent and –2.91 percent, respectively. Clearly, market participants believed that the new legislation was likely to impose strict and expensive new requirements for firms which slaughter animals.

Event 11 is the third type of significant regulatory event. Specifically, 11B is the passage of the Poultry Producers Financial Protection Act. This act gives specific financial guarantees to poultry producers. The significant negative AR of 3.82 percent can best be explained as a direct consequence of the fact that beef and pork processors are direct competitors with poultry processors. Thus, the financial support that this bill provides at the farm level may be viewed as providing an advantage to the poultry industry relative to the beef and pork industry.

Events 1, 3, 5, 7, 8, 9, and 10 were found to have no significant impact on the wealth of shareholders in the meat packing industry. Some likely reasons for the lack of significance are presented in what follows.

Event 1 is an act that restricts meat imports based upon the level of domestic meat production. Import restrictions are imposed only when a given trigger level of domestic production is reached. Event 7 amends the original Meat Import Bill of 1964 by engaging import restrictions based upon trigger levels that are calculated using a countercyclical formula. The countercyclical trigger is used in an attempt to smooth out domestic meat supply through a formula that assumes that domestic production moves naturally in a cyclical fashion through time and that the domestic supply can be smoother if the trigger, which imposes import restrictions, accounts for this "natural" cycle.

The lack of significant results for event 1 suggests that the initial import restriction program passed in 1964 did not induce a dramatic change in the supply of meat for processing in the United States. That is, the supply of meat to processors was not impacted enough by import restrictions to alter input costs to the extent that the long-run profits of processors were significantly impacted. This conclusion is reinforced by the fact that no import restrictions were triggered for meat products until 1968. Specifically, domestic production levels for meat products were not high enough to cause restrictions to be imposed during the 1965-67 period. Therefore the program provided no reduction in import levels during these years (U.S. Meat Import Law).

The lack of significant results for event 7 can probably be attributed to the fact that the addition of the counter-cyclical provision to the import law did not significantly alter the impact of the original bill. Simpson examined the behavior of the amended trigger mechanism under the 1979 counter-cyclical bill, for different states of the world, and he concludes that "The apparent

similarity of trigger levels under two radically different projections is an indication that, despite beliefs to the contrary, the 1979 bill cannot be considered particularly beneficial to the United States or exporting nations." Thus, the result in the present study appears to be in agreement with earlier evidence.

The lack of significant results from testing event 5 is relatively easy to explain. The development of OSHA and it's powers to oversee and regulate industry developed over many years. The specific duties and regulations that would be associated with OSHA were not known at the time the agency was created. Thus, any impact on the industry examined in this study would have been purely speculative.

Events 3 and 8 are similar events in that they modify inspection, packaging and labeling legislation and thus are logical extensions of existing legislation associated with events 2 and 4. It is worth noting that the original Fair Packaging and Labeling Act did have significant industry impacts while modification to the legislation seem to be of much less importance.

Events 9 and 10 had no significant impact on the industry. Event 9, the Dairy and Tobacco Adjustment Act, contained provisions designed to reduce milk supplies by paying dairy farmers to reduce their milk output. Increased culling was one possible method available to farmers for achieving the reduced output. The potential reduction in herd size, through culling, would primarily be a consequence of this paid milk diversion. For event 10, the whole-herd buyout program, there was a similar effect on the supply of animals for slaughter. Specifically, the federal government bought entire dairy herds in an attempt to reduce the production of milk. These dairy cattle were to be exported or slaughtered in the United States. The actual number of dairy cows slaughtered under the whole-herd buyout program outnumbered the quantity of livestock that farmers intended to slaughter under the milk diversion program. These results consistently indicate that dairy programs have little impact on the industry, probably because of the relatively short-run nature of the impact on the supply of animals available for slaughter. That is, while the short-run profit impact may be substantial the long-run effect is minor.

Summary and Conclusions

This study has examined the reaction of stock prices in the meat packing industry to changes in federal regulations and farm programs that were hypothesized to impact the industry. As such, this study builds upon the results of previous event studies in determining conditions under which different types of regulations will impact the wealth of shareholders. Three general conclusions are supported by this study: 1) regulatory actions, such as safety and inspection programs, that increase processing costs can actually increase shareholder wealth if increases in demand due to increase in quality are expected to outweigh the impact of increased costs; 2) regulations affecting costs of slaughter can significantly impact the industry; and 3) market participants are adept at analyzing the net impacts of regulations.

The specific results of regulatory event testing show that many regulatory changes produce significant impacts on the meat processing industry, in this study shown to be as large as 4 percent of shareholder wealth for a single informational event. The effect of each specific regulatory change on shareholders is dependent upon the type of regulation examined. Such large impacts on the wealth of shareholders suggest that regulatory agencies and the regulations they create often serve the industry and the public by reassuring the public that the food supply is safe. It is suggested that these effects are large enough to create longterm impacts on the industry and should therefore be further investigated for other processing industries. On a methodological note, we believe that future researchers will find that the Scholes and Williams approach, which adjusts for the existence of nonsynchronous trading, will be especially useful in future event studies involving other agricultural subsectors because many agricultural processing industries have a large number of smaller, lightly traded firms.

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Economic Feasibility of Farm Real Estate Equity Investments

Charles B. Dodson

Abstract. *The potential for investment by nonfarm investors in U.S. farm equity is estimated by applying a micro-model of the nonfarm equity market to USDA's Farm Costs and Returns Survey. The analysis indicates a potential market from farm operators of approximately $9 billion. Establishment of real estate investment trusts (REIT's) is discussed as a possible institution to unite farmers and investors.*

Keywords. *Real Estate Investment Trusts, equity financing, farm real estate, farm returns, Farm Costs and Returns Survey.*

Historically, farm businesses have raised capital from owner equity, debt financing, or leasing. Nonfarm businesses, on the other hand, can raise capital through various other financial instruments such as stock, limited partnerships, real estate investment trusts (REIT's), and leases. Production agriculture's unique structural characteristics have restricted the use of these capital sources. These restrictions have impacts on the growth, liquidity, inter-generational transfers, and risk-return tradeoffs of farm businesses. This paper examines the potential market for external equity investments in farm businesses.

Possible forms of external equity investments along with advantages and disadvantages of external equity financing have been the topics of previous studies (Lowenberg-DeBoer et al; Fiske et al.; Matthews and Harrington; Raup; Crane and Leatham).[1] Economic models of investor and farmer behavior with respect to external equity have also been presented (Collins and Bourn; Penson and Duncan; Moore). The current literature on external equity for equity, however, includes few studies which focus on the market potential. A lack of detailed farm-level financial data has restricted attempts to empirically estimate the non-farm equity's market potential. USDA's Farm Costs and Returns Survey (FCRS) provides this information.[2] This paper contributes to the literature by developing empirical estimates of potential demand for nonfarm equity from farm operators using FCRS data.

Capital Sources for Farm Businesses

Farm businesses require capital to expand or take advantage of new technology. Farm businesses with insufficient owner equity to meet their capital requirements have relied on debt and/or leasing as the primary sources of additional capital. A major disadvantage of debt financing is the increased financial risk of a farm business. The farm financial crisis of the 1980's provides an example of the risk imposed on farm businesses and the farm sector as a result of debt financing. Lower commodity and land prices along with higher and more volatile interests rates during the 1980's lowered the return to farm assets and increased financial risk thus contributing to a significantly higher incidence of credit problems, loan delinquencies, foreclosures, and bankruptcies.

The greatest capital investment for most farm businesses is real estate. Leasing is a prevalent method in which farm operators acquire real estate for expansion. Forty-two percent of all farm real estate is operated under some form of leasing arrangement. Nearly two-thirds of all leased acreage is cash leased the remainder covered under type of share arrangement (USDA FCRS, 1991). Cash leases suffer from the same disadvantages as debt financing since they involve a fixed obligation. Share lease arrangements result in less financial risk for the farm business since they are based on a proportion of production.

Both share and cash leases, however, have several disadvantages compared to direct ownership. Lessees have no right to the residual value of the asset and can result in agency costs. In the case of agricultural real estate, a lessee has less of an incentive to maintain buildings, access roads and

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[1]Sources are listed in the References section at the end of this article.

[2]The Agricultural Economics and Land Ownership Survey (AELOS) also includes much of this information (U.S. Department of Commerce; 1990). AELOS has an advantage over FCRS in that it includes information on landlords and operators. FCRS includes information on operators only. AELOS, however, includes information for 1988 only which was a drought year in the Midwest and parts of the South.

fences, or prevent erosion. Lessors may seek to protect the residual values by incorporating control practices into the lease agreement. However, this increases negotiation costs for both the lessee and lessor. In searching for land, lessees may face high costs of search and assessment of quality.

External equity arrangements may offer several advantages over leasing. There are less concerns about the protection of residual value since each party has an interest in the property. As an owner of the property, the operator avoids the possibility of annual search costs.

A large proportion of farm businesses may require capital to facilitate inter-generational transfers of estates. USDA data indicates a large portion of farm assets are held by farmers who are at or near retirement age. Farmers over 55 years of age control 46 percent of all farm assets while farmers over 65 years of age control 21 percent of all farm assets (USDA Farm Costs and Returns Survey; 1991).

The large investment by farm businesses in real estate has implications for short-term cash management and investment options. Farm businesses with short-term cash-flow problems cannot easily liquidate real estate investments to meet cash-flow shortfalls. Illiquidity can also limit a farm operator's investment choices. A farm operator with little liquidity cannot easily take advantage of opportunities to purchase new land or equipment. The large land investment required by farm businesses can cause the farm operators' investment portfolios to be subject to unsystematic risk. The wealth of a farm operator whose investments consisted entirely of agricultural assets would be vulnerable to changes in land values. This vulnerability could be reduced if an operator could sell equity interests to nonfarm investors and use the proceeds for diversification into non-farm investments.

The disadvantages associated with debt and leasing indicate a need to further examine alternative sources of capital for the owner/operators of farm businesses. If markets for farm equity existed, farm businesses could raise capital for investment by selling equity interests to non-farm investors. Compared to debt financing or cash leasing, external equity arrangements result in less financial risk. Compared to the exclusive use of owner equity, external equity arrangements enable leveraged investments and reduced unsystematic risk for the farm operator. Compared to share leasing, external equity investments enable the farm operator to have an interest in the residual value. The organizational structure of production agriculture and the transaction costs of establishing an external equity market have restricted the development of market mechanisms to channel equity from the non-farm sector to the farm sector. An institution or single investor seeking to invest in farm businesses would likely incur significant search, information, and monitoring costs which may discourage the direct or shared ownership of farm assets. Existing market mechanisms, such as going public, selling shares of common stock, or establishment of limited partnerships, can involve high start-up costs, even for large commercial farms. On the other hand, evidence suggests that agricultural assets generate sufficient returns to be attractive to investors (Barry, Gertel and Lewis, Moss et al., Dodson).

A flow of capital from the nonfarm investor to farm businesses requires: (1) a sufficient number of farm businesses which meet a minimum return and size criteria; (2) a sufficient number of farmers willing to participate in an equity market; and (3) an institution which unites farmers and investors and lowers transaction costs. The objective of this study is to estimate the potential market for U.S. nonfarm or external equity by incorporating the aforementioned requirements into a micro-model for farmers' demand for external equity and investors supply of capital to agriculture.

Because agricultural real estate is nondepreciable and often cited as a good inflation hedge, it is an attractive investment. Farm businesses also require capital for livestock, machinery, and equipment. The shorter life and depreciability of nonreal estate assets make them attractive for equity investments. Investors and farm operators are not likely to want to the incur origination costs for shortterm external equity investments. Also, investors are not likely to incur the cost of regularly monitoring and valuing depreciable assets such as machinery. Because farm real estate represents the asset most likely to attract the interest of investors, it is the focus of this analysis.

Establishment of REIT's for agricultural real estate investments is discussed as a possible institution to unite farmers and non-farm investors. Assumptions concerning transactions cost of establishing and maintaining an agricultural REIT are incorporated as well as minimum size and returns of farm businesses. Estimates of the potential market are based on the financial characteristics of farm businesses over the 1987-91 period as obtained from USDA's Farm Costs and Returns Survey.

Relation to Previous Studies

Several previous studies have presented economic models of investor and farmer behavior which incorporated external equity. Penson formulated a growth model which included external equity infusions. Moore demonstrated the demand for external equity is a derived demand analogous to a production input. Matthews and Harrington discussed the possible forms of non-farm equity and the merits of each. Lowenberg-DeBoer et al., graphically presented the limitations and weaknesses of debt financing. Leathem and Crane discussed the principle of Islamic banking as a method of relaying external equity from investors to farmers. Fiske et al. discussed the historical pattern of capital flows in agriculture and implications for future capital flows. Collins and Bourn explored the economic conditions in which the external equity capital market could exist and suggested institutional structures for delivering external equity. According to Collins and Bourn, "For external equity to be a significant source of equity for farm businesses, the transaction must be viewed as being beneficial by all parties ...." Collins and Bourn's approach was to derive micro-models of farmer and investor behavior and determine whether these models intersect at a meaningful equilibrium. This research develops an empirical application of the Collins and Bourn model utilizing FCRS data.

The Collins and Bourn Model

Collins and Bourn developed models of both farm operator demand and investor supply. The Collins and Bourn model depicted an exchange of external equity for bank debt. Application of their models to empirical data provides estimates of the amount of debt farm operators would be willing to exchange for external equity. This procedure would likely provide conservative estimates since the approach does not recognize the impacts of the availability of external equity would on a farm operator's investment decision. For example, the availability of external equity may encourage greater expansion through acquisition of land or improvement of facilities. Also, farm operators may sell their own equity to investors in order to reduce unsystematic risk or increase their liquidity. Another possibility is that the availability of external equity may encourage farm operators to substitute external equity arrangements for leasing. The subsequent analysis should be interrupted as an estimation of external equity demand by farm operators under the conditions of a debt-equity swap.

Collins and Bourn defined the price of external farm equity as:

$$\gamma = \frac{\pi}{E/A}, \qquad (1)$$

where π is the proportion of the profit received by the investor; E is the equity supplied by investor; A is the total value of farm assets; and γ is the price of equity. A price of equity equal to 1 implies a return to the investor in direct proportion to the investment. In return for contributing "X" percent of the total investment, an investor would receive "X" percent of total returns. Low farm business returns may not necessarily result in an investor not supplying capital. The investor may simply require a greater proportion of income relative to their investment.

For a farmer, the price of external equity is the proportion of returns one would be willing to give up to attract investment. Risk aversion, the cost of debt relative to the cost of equity, and taxation are factors which may cause the farmer's price of external equity to deviate from unity. A highly risk averse farmer, for example, may be willing to forgo income for equity to avoid the financial risk associated with leverage.

The derived demand for external equity shown by equation (2) corresponds to Collins and Bourn's equation (10).

$$E = \frac{A - \gamma\,[R - KD - \rho\sigma_R^2\,\tau]}{2K\gamma + \rho\sigma_R^2/A\ \gamma 2\tau}, \qquad (2)$$

where E is the dollars of external equity; R is the random net return to activities of the farm prior to interest and tax payments; A is the value of farm assets; K is the interest cost of debt; D is the volume of outstanding debt; ρ is a risk aversion coefficient; τ is one minus the state plus federal marginal tax rates on personal income, and σ_R^2 is a measure of variance of farming returns. Collins and Bourn demonstrate that the partial derivatives of (2) all have the expected signs implying more profitable farms should be less interested in an exchange of debt for external equity while farmers operating in a riskier environment and farmers which are more risk averse would be inclined to exchange debt for external equity.

A reservation price of external equity for a farm operator (γ_f) is defined as the price of equity (γ) which makes the numerator of (2) positive:

$$\gamma_f = \frac{K}{r - K\delta - \rho\ C\tau}, \qquad (3)$$

where $C = (\sigma_R^2/A)$, r is the expected return on assets, and δ is the debt-asset ratio.

An external equity market transaction requires a positive intersection of the investor's supply intersect and farmer's demand. Investors should be willing to supply external equity to an agricultural producer as long as the expected rate of return on agricultural assets at least equals the investor's required rate of return. The investor's rate of return (K_e) is determined by farm profits and the investor's reservation price of equity (γ_I).

$$K_e = \gamma_I \frac{[R - K * (D - E)]}{A}, \tag{4}$$

where R denotes the expectations of investors as to the net returns to the farm business. The numerator of equation (4) reflects the interest savings to the farm business as a result of the debt/equity swap, $(K * (D - E))$. At a price of equity equal to one the investor would receive the same rate of return as the farm business.

The investor's reservation price for external equity (γ_I) is determined by the relationship between an investor's required return and the expected farm return. The investor's required return represents the rate required by the investor as compensation for the systematic risk of the investment. An investor's required rate of return can be approximated using capital market theory. Market models such as the Capital Asset Pricing Model or Arbitrage Pricing Theory establish the required rate of return to be equal to the riskless rate, rf, plus a risk premium commensurate with the asset's systematic risk. Using β_a to represent systematic risk of the asset and r_{Aj} to represent the investors required rate for period j and $(r_{mj} - r_{fj})$ to represent the market risk premium, the CAPM indicates a required rate of

$$ra_j = rf_j + \beta_a(r_{mj} - r_{fj}), \tag{5}$$

where ra_j is the rate required on agricultural investments in period j. In equation (5) the market risk premium is defined as the market return in period j, (r_{jm}), less the risk free rate in period j, (r_{fj}). If the investors required rate is greater than the expected rate $(r_{Aj} > K_e)$, the investor would require a share of profits greater than their share of the investment. The investor's reservation price would thus be,

$$\gamma_I = \frac{r_{Aj}}{[R - K (D - E)]/A}. \tag{6}$$

Thus, the individual farmer's demand for equity is a function of the price of equity (γ), risk aversion (ρ), farm returns (R), variance of returns (C), taxes (τ), farm debt (ζ), and cost of debt (K). In functional form this can be represented as,

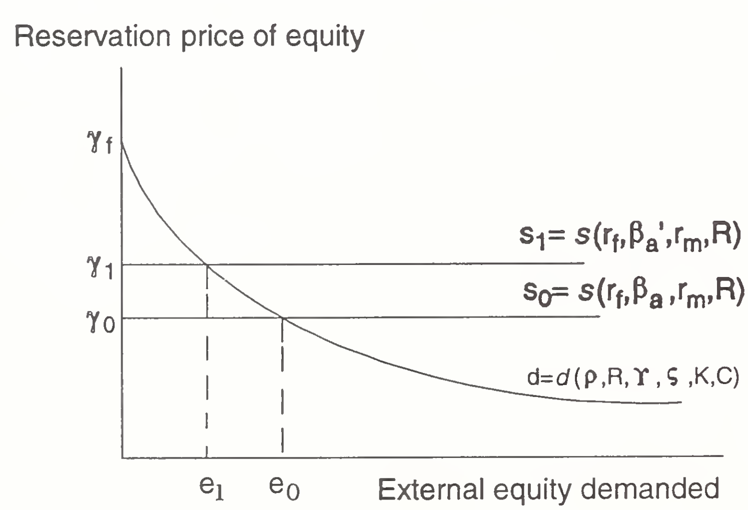
$$d = f(\gamma,\rho,R,K,\zeta,\tau,C), \tag{7}$$

where d is the estimated demand for external equity. Graphically, the demand for external equity is a declining function of the price of equity with risk aversion, farm returns, variance of returns, taxes, and cost of debt are demand shifters (fig. 1). Equity supplied to a farm owner/operator is a function of the risk free rate (r_f), the systematic risk of agricultural assets (β_a), the market return (r_m), and the farm return (R). In functional form this is represented as:

$$s = f(r_f,\beta_a,r_m,R), \tag{8}$$

where s is the amount of external equity supplied to an individual farm operator. This supply is perfectly elastic reflecting the lack of influence an individual farmer has on the aggregate return required by investors (fig. 1). From equation (3), the farmer's reservation price is the intercept of the farmer demand schedule and the vertical axis as shown by γ_f. The investors reservation price is represented by the intercept of investor's supply schedule. An individual farmer should participate in a market for external equity if the farmer's reservation price exceeded the investor's reservation price ($\gamma_f > \gamma_i$). At a reservation price for the investor of γ_0, the farmer would demand e_0 of external equity. Any factor which causes the investor's required return to increase would consequently result in a decrease in the amount of external equity demanded. For example, an overall increase in the systematic risk of agricultural assets (β_a) would cause an upward shift in the investor's supply from s_0 to s_1 and corresponding reduction in the amount of external equity demanded from e_0 to e_1.

Figure 1
Farm level demand and supply of external farm equity



Empirical Estimation of the Potential Market

In addition to an intersection of investor supply and farmer demand at a meaningful equilibrium, an institution must exist to unite suppliers of external equity with the farm owner/operators. In commercial real estate, REIT's have represented institutions which have been successful at accomplishing this task. A REIT is a corporation formed for the purpose of holding real estate and is taxed as a partnership. First created by Congress in 1960, REIT's were designed to allow large groups of small investors to purchase stakes in real estate ventures. Typically, REIT's issue common shares which can be traded over the counter or on organized stock exchanges. REIT's vary in structure. Some own and manage properties, some make and manage real estate loans, some do both. REIT's which own and manage properties are the type considered in this analysis.

Establishment of a REIT can involve substantial fixed costs such as underwriting and other associated legal fees requiring a large volume of investments over which to spread the cost. The feasibility of agricultural REITs obviously depends on a sizable proportion of farm businesses with returns sufficient to attract non-farm investors. Farm businesses which provide returns to investors greater than received on alternative investments would attract interest from non-farm investors. Several studies have shown that agricultural assets have little or no systematic risk (Barry, Irwin et al.; Dodson). Thus, with no transactions cost, agricultural investors would require rates of return approximately equal to the risk free rate approximated by U.S. Treasury bills.

The proportion of farms with returns greater than Treasury bills can be estimated using FCRS data. The FCRS details expenses, income, assets, debt, and many other items disaggregated by production region, farm size, production specialty and other characteristics. From the FCRS, specific information is obtained concerning a farm business's indebtedness, cost of debt, return on farm assets, and value of assets.[3] The return on farm assets from current income is added to an estimate of capital gains to obtain a total return on farm assets. Capital gains are estimated by application of the annual change in average per acre land value for the state in which the farm is located to farm real estate values. Land value data is obtained from "Agricultural Land Values and Markets Situation and Outlook" published by USDA. The total returns for a sample farm for 1991 are calculated as:

$$R^{i}_{91} = ROA^{i}_{91} + CGAIN^{j}_{91}, \tag{9}$$

where R^{i}_{91} is the total return on assets for farm i in 1991; ROA^{i}_{91} is the return on assets received from current income in 1991 for farm i as determined from the FCRS; and $CGAIN^{j}_{91}$ is the capital gain on farm real estate assets located in state j in 1991.

In 1991, approximately 14 percent of all of farm businesses provided total returns on assets which were equal to or greater than the rate on 3-month treasury bill (table 1). Farm businesses which provided returns greater than Treasury bills were typically large, located in the Midwestern production region, and specialized in the production of corn-soybeans or red meat animals (table 2).[4]

Farm businesses with returns greater than Treasury bills held 28 percent of total farm operator suggesting a sizable market potential for non-farm equity (table 1). In addition to adequate returns, investor's may require farm businesses to meet a minimum size requirement. Investors may also require an additional premium to cover intermediation costs. Some states have restrictions which prohibit ownership of farmland by corporations or limited partnerships. Eleven states had statutes which restricted or prohibited corporate ownership of farm land over the 1987-91 period (Aiken).[5] Even if a farm business has sufficient size, returns, and location to meet an investor's criteria, the farm owner/operator may still choose not to participate. As shown by equation (2), an individual farm operator's demand for external equity depends on unique characteristics which include indebtedness, risk attitudes, and farm profitability.

An empirical approximation of a farm operator's demand for external equity is estimated by applying the individual demand model shown in equation (2) to FCRS farm level data. Investors would likely expect compensation for intermediation costs which include origination fees and annual servicing fees. As in the Collins and Bourn analysis, a 6-percent one-time origination fee and a 2.2

[3]Detailed discussion of the FCRS is available in USDA publications (Morehart, Johnson, and Banker, et al.).

[4]For description of regions see app. table 6 in Morehart, Johnson, and Banker. The Midwest region used in this analysis is an aggregation of the USDA's Lake States and Corn Belt. The Plains region is an aggregation of Northern and Southern Plains. The South region is an aggregation of USDA's Southeast, Delta, and Appalachia regions while the West is an aggregation of the Mountain and Pacific regions.

[5]These states include Arizona, South Dakota, Illinois, Minnesota, Iowa, Missouri, Kansas, North Dakota, Louisiana, Oklahoma, and Wisconsin.

Table 1—Percentage of farm operator debt and farms with total returns greater then 3-month Treasury Bill rates by farm size

	1987	1988	1989	1990	1991	5-Year Average
			percent			
Proportion of total farms						
$250,000 and over	4	3	3	3	3	3
$100,000 to $249,999	13	11	8	8	6	9
Less than $100,000	14	11	7	6	6	9
All sizes	31	25	18	17	14	21
Proportion of farm operator debt						
$250,000 and over	20	17	16	18	17	18
$100,000 to $249,999	24	16	14	13	10	16
Less than $100,000	6	4	3	2	2	4
All sizes	49	37	33	34	28	38

Source: USDA Farm Costs and Returns Survey

Table 2—Distribution of farm operator debt held by U.S. farms with total returns greater than 3-month Treasury Bill rates

	1987	1988	1989	1990	1991	5-Year Average
			percent			
By farm size:						
$250,000 and over	40	47	49	55	59	48
$100,000 to $249,999	48	43	42	38	34	42
Less than $100,000	12	10	10	7	7	9
All sizes	100	100	100	100	100	100
By production region						
Northeast	5	9	4	3	5	5
Mid-west	49	38	34	41	37	41
South	13	13	16	10	13	13
West	18	22	21	23	24	21
Plains	15	19	25	23	21	20
All regions	100	100	100	100	100	100
By production specialty						
Corn-soybean	24	22	20	18	24	22
Wheat & Barley	5	5	6	5	8	6
Tobacco	1	1	1	1	2	1
Cotton	4	2	2	2	2	2
Fruit & nut	2	4	4	3	3	3
Beef, hog, sheep	24	30	24	26	20	25
Dairy	18	18	14	17	12	16
All other types	22	18	28	28	28	25
All types	100	100	100	100	100	100

percent annual servicing fee are assumed. The investor's required return is estimated using the 3-month Treasury bill rate with adjustments made for intermediation costs as shown by equation (10).

$$r^*_{Aj} = \{r_f * (1 + \text{origination fee})\} + \text{servicing fee}, \quad (10)$$

were r^*_{Aj} represents the return required by investors after adjusting for costs of intermediation; r_f is an annual rate for 3-month treasury bills.

The fixed costs associated with originating an equity investment in an agricultural REIT would probably lead to the exclusion of many smaller farm businesses. This is similar to the minimum farm loan size requirement instituted by life insurance companies. Minimum size requirements instituted by life insurance companies range from $100,000 to $500,000 (Thompson).

Baseline analysis

A baseline analysis is undertaken in which it is assumed than a farm business must have at least $100,000 in farm real estate assets to be considered for an external equity investments. Farm businesses located in states which prohibit corpo-

rate ownership of farm land are excluded from the baseline analysis. Farm operators are assumed to be risk averse with $\rho = 10^{-5}$.[6]

The Collins and Bourn model suggests that an individual farmer's demand for external equity is influenced by expected farm returns, capital gains, taxes, and cost of debt. Since the data only covered 5 years (1987-91), it was not possible to develop expectations of these variables using time series relationships. Alternatively, farmers are assumed to formulate expectations using a naive framework where the return on assets from the previous year approximates future returns. Also, expected cost of debt is based on the average cost of debt from the previous year. Expected capital gains are based an USDA forecasts of changes in land values (U.S.D.A., "Proceedings Outlook"). The marginal tax rate (τ) used in the analysis is the marginal federal tax rate of 28 percent plus the top marginal rate for each state (U.S. Department of Commerce, 1992). An estimate of variance of net returns is obtained by disaggregation of FCRS data by production specialty, farm size, and region into over 100 distinct categories. Variance of total return on assets is approximately over the 1987-91 period for each of these categories. These estimated variances are assigned to each sample farm based on the farm's productions specialty, size, and region.[7]

Obviously, the use of naive forecasts for farm returns could result in biased estimates if the base year is untypical. Thus, the results presented in subsequent tables and figures represent 4-year averages which are derived by application of the model over the 1988-91 period.[8] The aggregate amount of non-farm equity demanded by farm operators is estimated by an aggregation of the demands by individual farm businesses.

Results obtained from application of the equation (1) to the data indicated that in 1991, only 2.58 percent of farms would be expected to demand external equity. A potential market from farm operators of \$9.5 billion is indicated with a majority of the demand among farms with annual sales greater than \$250,000 and with debt-asset ratios less than 0.40 (table 3).[9] Demand is divided between crop and livestock farms with largest portion of total demand contributed by dairy, beef-hog-sheep, and corn-soybean production specialities. The Western production region is an area with strong market potential with 45 percent of the total U.S. demand for external farm equity. Also, producers of fruits and nuts, nursery products, and vegetable represent a large proportion of the potential market with approximately 15 percent of the total demand. The average equity investment per farm was \$265,603. The largest external equity investment per farm occurred on farms in the Western region. On average, farms with over \$250,000 in annual sales had an equity investment of \$416,800.

The operators of highly leveraged farms which were indicated to participate in external equity markets have relatively high rates of return. Conversely, participants with lower leverage have relatively low rates of return. A possible explanation is that farm businesses which borrow smaller amounts may be unable to negotiate favorable rates from lenders. Consequently, these farms stand to gain more from an external equity investment because of the differential between the cost of equity and cost of debt. Farm businesses which borrow greater amounts may be able to negotiate more favorable rates from lenders. In this case participation in an external equity market occurs when the farm business provides a return sufficient to offer equity at a price less than 1 and still provide investors with their required return. For example, in return for a 10 percent investment an investor would receive 5 percent of profits.

Sensitivity analysis

Recent empirical studies have shown farm real estate investments to return significantly higher than comparable risk non-agricultural assets (Bjornson and Innes). Investors require higher returns because the assets are illiquid (Barry) and permit the owners limited diversification potential (Bjornson and Innes). Thus, the use of the Treasury bill rate as an approximation of the required return may overestimate the potential market. Estimation of the external equity demanded by farm operators at various rates of return required by the investor traces out an aggregate demand function. The aggregate demand function can subsequently be used to estimated

[6]Collins and Bourn describe this as a moderately risk averse farmer. An individual with $\rho = 10^{-5}$ would pay \$3,093 to avoid a 50-50 gamble where they would lose 50 percent of their \$250,000 wealth.

[7]Data were disaggregated in a manner described in "Profitability of Farm Businesses, A Regional, Farm Type, and Farm Size Analysis," an upcoming USDA Agricultural Information Bulletin.

[8]The 1987 FCRS data was not used to estimate demand because 1987 data did not separate real estate and nonreal estate debt.

[9]It should be noted that FCRS estimates include only farm operator debt used for farm business purposes. Therefore, the estimates for total debt are not the same as USDA's official numbers published in "Economic Indicators of the Farm Sector."

demand for external equity at various rates of required return. The baseline demand function incorporated the previously discussed baseline assumptions but varied the investor's required return from 0 to 30 percent. This baseline demand function is subsequently compared with demand functions which are estimated assuming risk neutrality, increases in the minimum investment size, removal of all state restrictions on corporate ownership of farmland, increased variance, and reduced debt cost.

The farm operator's demand for external farm equity as a function of investor's required return is graphically displayed in figures 2-6. The demand functions represent an average of the annual demands for 1988-91. As expected, required return is inversely related to the demand for external equity. An increase in demand for external equity due to an increase in the farm operator's risk aversion is a consequence of the lower financial risk of equity financing relative to debt financing (fig. 2).

Another major factor which should influence the demand for external equity is the differential between the cost of debt and equity. Farm businesses indicated to participate in the external equity market tended to have a high cost of debt relative to their returns.

Total return on assets for all farm participating in the external equity market was 7.6 percent compared to average cost of debt of 9.4 percent (table 3). In recent years interest rates have fallen enabling farm operators to lower their average cost of debt. The sensitivity of the results to a decrease in interest rates is analyzed by reducing the average cost of debt by 10 percent, or approximately 1 basis point. As expected, decreasing debt cost reduces the demand for external equity by approximately $500 million at a given interest rate (fig. 3).

Figure 2

The demand for external equity as a function of required investor return comparing risk aversion and risk neutrality

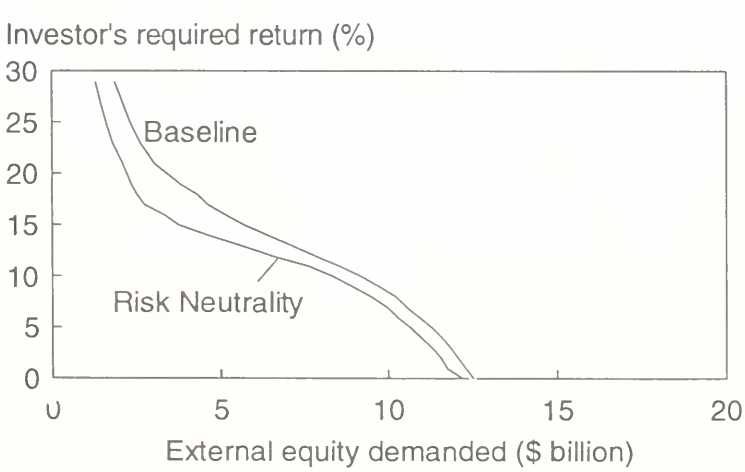


Figure 3

Demand for external equity as a function of required investor return estimated using the current average interest rate on real estate debt and the current average interest rate reduced by 10 percent

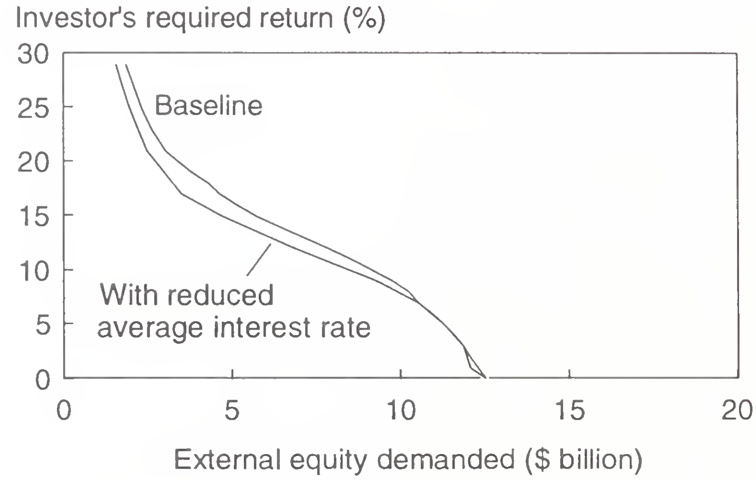


Figure 4

Demand for external equity with and without existing state restrictions on corporate ownership of farmland

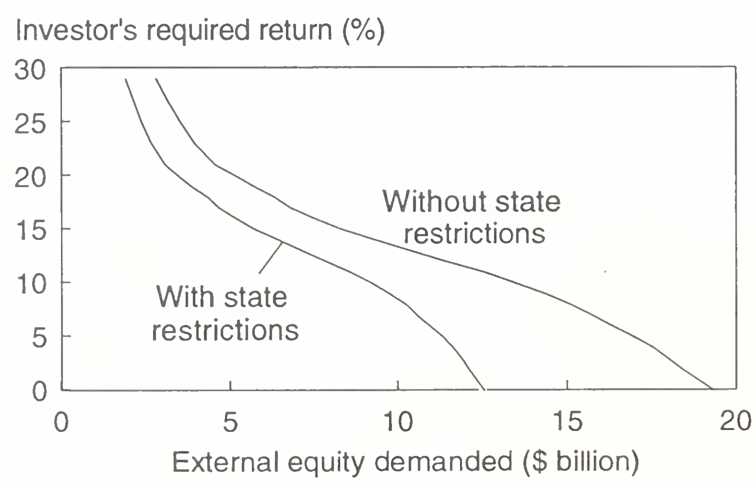


Figure 5

Demand for external equity as a function of investor's required return comparing minimum size requirements of $100,000, $250,000, and $500,000

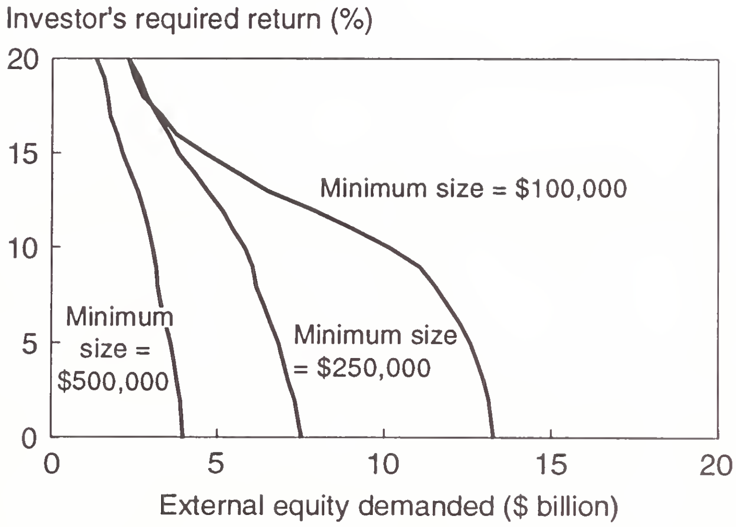
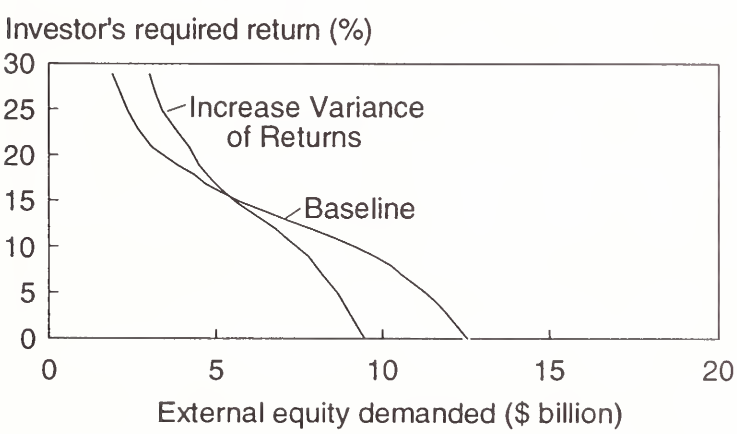


Figure 6

Demand for external equity as a function of required investor return estimated using baseline estimate of variance and increased variance



Relaxing the state restrictions on corporate ownership of farmland increase the demand for external farm equity (fig. 4). The large increase for external farm equity shown for the Midwest region signifies the frequency of state restriction among these states. With restrictions on corporate ownership, the Midwest region represents 21.5 percent of the total U.S. market for external equity (table 3). Removal of state restrictions increases the Midwest regions share of the total U.S. market to 36 percent and increases total U.S. demand from $9.1 billion to $14.1 billion.

Increasing the minimum investment size from $100,000 to $250,000 would reduce the quantity demanded from $9.1 billion to $6.2 billion at a required return for investors of 9 percent (fig. 5). Further increase in the minimum size requirements to $500,000 reduces quantity demanded to $3.5 billion.

The sensitivity of the results to changes in variance of farming returns is analyzed by doubling the standard deviation of total returns on assets. Equation 2 shows that an increase in variance should increase quantity demanded if R > KD. This is reflected in the estimated demand schedules which indicate that at lower required returns for investors, an increase in variance decreases quantity demanded (fig. 6). At higher required returns for investors, an increase in variance results in an increase in quantity demanded.

Summary and Implications

Farm operations are capital intensive businesses requiring substantial capital outlays. Farm operators have typically used bank debt, owner equity, and/or leasing as sources of capital. Each of these options, however, has disadvantages. Bank debt and cash leasing increases financial risk. Owner equity financing can subject the owner/operator to unsystematic risk and result in illiquidity. Leasing can result in high agency costs since the operator/lessee does not have an interest in the residual value of the assets. External or non-farm equity investments represent an alternative source of capital for farm operators which does not have the disadvantages associated with bank debt, owner equity, or leasing. A functioning market for external equity, however, would require sufficient interest on the part of both farm businesses and investors. Also, it would require the establishment of institutions which unite farm operators and investors. This study empirically estimates the market potential for external equity among farm operators under the conditions of a debt-equity swap. REIT's are suggested as a institution for uniting operators and investors. Intermediation and origination costs consistent with REIT's are incorporated into the analysis. Over the 1988-91 period, an estimated $9 billion of farm operator debt would have been exchange for equity.

The $9 billion probably represents a conservative estimate since the analysis does not consider the potential impacts that availability of external equity may have on investment decisions. A greater availability of external equity investments may encourage greater expansion by farm operators. Also, farm operators may sell their own

Table 3—Characteristics of farm businesses participating in proposed external equity market, by farm size, production region, and production specialty

	Farms	Total Assets per farm	External equity per farm	Percent of debt	Total external	Return on assets	Total Return on assets	Average cost of debt
	Number	---------Dollars---------		percent	$Thousands	---------------percent---------------		
All farms	35,907	1,062,698	265,603	100	9,538	7.2	7.6	9.4
By farm size								
Over $250,000	11,886	1,554,131	416,800	52	4,964	11.2	11.5	9.4
$100,000 to $249,999	12,121	780,477	202,648	26	2,456	6.1	6.4	9.3
Less than $100,000	11,900	859,304	178,707	22	2,127	1.1	1.8	9.5
By Debt-asset class								
0.01 to .10	1,895	2,870,173	196,756	4	373	3.2	3.6	9.4
0.11 to 0.40	22,101	1,108,888	251,847	58	5,566	6.8	6.8	9.5
0.40 to 0.60	7,658	760,252	296,313	24	2,269	9.0	9.3	9.2
Over 0.60	4,254	562,095	312,455	14	1,329	16.3	16.6	9.2
By production specialty								
Cotton	544	1,020,424	249,601	1	136	11.7	12.2	9.4
Wheat & Barley	1,445	1,247,867	332,786	8	481	6.0	6.3	9.6
Dairy	7,329	1,094,758	285,335	25	2,091	7.8	8.0	8.8
Tobacco	734	596,435	180,178	2	132	9.2	9.6	10.1
Corn-soybean	4,660	839,143	221,957	13	1,034	7.8	8.0	9.4
Beef, hog, sheep	7,509	1,169,374	269,147	17	2,021	5.3	5.8	9.4
Fruit & nut	3,492	1,357,073	281,868	6	984	4.2	5.1	9.6
Other Types	6,968	1,095,285	274,214	27	4,680	6.8	6.9	9.5
By production region								
Baseline analysis:								
Northeast	2,947	962,353	230,921	4	681	7.3	7.5	9.1
Mid-west	8,456	877,628	241,966	27	2,046	7.8	8.3	9.1
South	7,833	794,526	216,998	23	1,700	8.3	8.8	9.7
West	12,686	1,394,438	323,766	37	4,107	6.4	6.7	9.5
Plains	3,986	1,000,700	251,799	10	1,004	8.2	5.3	9.1
No state restrictions on corporate ownership:								
Northeast	2,947	962,353	230,921	4	681	7.3	7.5	9.1
Mid-west	21,758	869,685	233,106	27	5,072	7.2	7.7	9.0
South	8,031	796,337	217,714	23	1,749	8.6	9.0	9.7
West	12,962	1,397,385	326,209	37	4,228	6.5	6.8	9.6
Plains	9,369	906,554	247,910	10	2,323	8.1	8.5	9.0
All regions	55,067	1,062,698	265,603	100	14,053	7.2	7.6	9.4

Source: USDA FCRS

equity to investors or substitute external equity arrangements for leasing. The impact that the availability of external equity investments may have on investment is a topic left for further research.

In addition, the $9 billion estimate only considers demand by farm operators. The Collins and Bourn model is based on farm operators only and did not consider landlords. Landlords, however, hold only 8 percent of total farm debt in the U.S. (U.S. Department of Commerce, 1990). Hence, they are not likely to contribute significantly to total demand for external farm equity under the conditions of a debt-equity swap.

Proposals designed to encourage non-farm investment in farm businesses are likely to be politically unpopular with groups interested in preserving agrarian principles. However, this analysis indicates economic gains to both investors and farm owner/operators. Investors would benefit through capital gains and shares in operating income. Farm operators would benefit through an additional source of capital for financing investment. The availability of external equity to farm operators should enable farm businesses to expand without relying on debt, leasing, or owner equity. External equity is less risky than debt or cash leasing and enables the operator to share in capital gains. Moreover, external equity enables farm operators to diversify their wealth to non-agricultural investments and thus reduce their unsystematic risk.

Origination fees and servicing costs compatible with REIT's are assumed. This resulted in an average required return over the period of approx-

imately 9 percent. Sensitivity analysis indicated that even with a required rate of 20 percent, a potential market of approximately $3.5 billion still exists. State statutes restricting corporate ownership of land restricted the potential for external equity markets. This is especially true in the Midwest production region. These laws may have been originally intended to protect agricultural interests. However, the harmful effect of these laws on the availability of capital to farm businesses should be recognized.

This analysis suggest that there is a potential market for external equity. The question is whether sufficient volume would be generated to justify establishment of specialized REIT's. The market size indicated by this analysis may be too small for a specialized agricultural REIT. Established REIT's in other sectors, such as commercial real estate, could diversify into agriculture. Smaller institutions such as real estate limited partnerships (RELP's) are also alternatives. The Farm Credit System could solicit and construct agricultural investment packages for sale to investors.

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Economic Issues in Global Climate Change: Agriculture, Forestry, and Natural Resources. *Edited by John Reilly and Margot Anderson. Boulder, CO: Westview Press, 1992, 460 pages, $52.00 (softcover).*

Reviewed by LeRoy Hansen

Research on global climate change has been spurred by the increasing acceptance that human activities have induced climate change. Uncertainties in the physical science of climate change are significant. There is considerable uncertainty as to the relationship between the release of "greenhouse gases" and their accumulation in the atmosphere as their life and potential to be absorbed by the sea remains uncertain. Greenhouse gases, such as CO_2, CH_4, N_2O, and CFC's, allow radiation from the sun to reach the earth but hold back the heat that would normally radiate into space (radiative forcing). Some argue that, despite greenhouse gas accumulation, the extent of climate change will be much less than forecast because cloud cover will increase with temperature and reflect solar radiation away from the earth. These arguments aside, significant uncertainties remain as to the rate and geographic distribution of climate change thus complicating economic analyses on global change. Given the popular acceptance of human-induced global climate change has come only recently, it is not surprising that economic analysis in the area is in its infancy.

The economist interested in impacts of global climate change in any sector of the economy will find portions of this book very helpful. The book begins by covering the science of global change and explains many commonly used terms. Additional topics covered include: the north-south debate (richer countries can afford adaptations to climate change more than poorer ones); efficiency versus equity (do future generations have an adequate say in determining the rate of greenhouse gas emissions?); and control of trace-gas emissions and devising an optimal trace-gas index (where the life, radiative forcing, ozone depletion and other environmental impacts of a greenhouse gas are considered). The reader will notice that issues raised by the author(s) of one chapter may differ philosophically with work author(s) of other chapters. Consequently, the reader realizes the extent of issues debated in economic analysis of climate change.

Reilly and Anderson attempt to provide a "starting point for researchers who are evaluating the economics of global change" and I believe they have succeeded for economists concerned about global change and agriculture. However, having "Agriculture, Forestry, and Natural Resources" in the title wrongly suggests comparable coverage on the effect of climate change in each of these areas.

The coverage of agriculture is to be complimented. Economists interested in initiating research on global climate change and its effect on agriculture will find these chapters a good place to start. Theoretical models, empirical studies, and the need for additional data are all discussed. Furthermore, chapters dealing with other physical (e.g., increased weather variability) and social (e.g., uneven distribution of impacts) considerations offer a near complete background for the beginner.

The coverage of forestry is limited. Only two of the four chapters in the forestry section focus directly on forest management under a changing climate. The other two forestry chapters look at forestation of agricultural lands as a means of sequestering carbon and, therefore, are chapters well worth including as an agricultural topic.

The coverage of natural resource issues is limited to agriculture's and forestry's dependance on resources. There is no valuation of global climate change impacts to the recreational uses or preservation of natural resources. This is not to say that authors of some chapters do not recognize that these values exist. For example, Bowes and Sedjo point out that forested areas in the Midwest may have a greater value as a recreational resource than as a forestry resource; and Easterling, et al. point to the potential conflict between water demands for fish and wildlife and water demand of agriculture.

The editors are not providing a product for the policy maker but for the research economist. However, policy makers could benefit from the chapter by Lewandrowski and Brazee who provide a clear, concise, and not-too-technical argument on the importance of allowing farmers greater flexibility in cropping practices to more efficiently adapt to climate change. This strikes me as an especially important point for two reasons. First, adapting farm programs as the climate changes relies on a political concensus recognizing a change. However, because climate change is a

gradual process thus making it difficult to recognize, program adoptions may never be made. (There are those who do not believe that climate is changing.) Second, flexibility encourages farmers and input suppliers to be more innovative so that impacts of climate change to agriculture can be reduced.

The reader may want to read chapter 21 before the earlier chapters that deal with quantitative assessments of the impacts of climate change. While writing it as a review chapter, Sonka focuses primarily on outlining an effective framework for evaluating strengths and weaknesses of quantitative assessments. When read before the quantitative chapters, the reader will gain a better perspective of the purposes, strengths, and relevance of the empirical work.

Reilly and Anderson "attempt to rectify the scarcity of economic analysis within the global change debate." The economic analyses of climate change presented are all still in progress. Given recent beginnings of economic analyses in this area, it is not surprising that no single chapter tackles the estimation of climate change impacts given the interrelationships between local, national, and international productivity and market impacts. However, the reader will find that, together, the chapters dealing with the economic impacts of climate change to agriculture do cover approaches in each of these areas. One can criticize any of the climate change impact analyses for not being more inclusive or for being too narrow in scope. However, research in this area has just begun. While these chapters do not provide policymakers with specific numbers for policy implementation, they do offer economists a blueprint to draw upon.

The papers include: Part 1—Overviews: 1. "The Science of Global Change: An Illustrated Overview" by Daniel L. Albritton; 2. "Comprehensive and Market-Based Approaches to Global-Change Policy," by Richard B. Stewart; Part 2—Broader Perspectives: 3. "Sustainability and Intergenerational Environmental Rights: Implications for Benefit-Cost Analysis," by Richard B. Norgaard and Richard B. Howarth; 4. "Agriculture in a Comprehensive Trace-Gas Strategy," Jae Edmonds, John M. Callaway, and Dave Barns; 5. "Climate Change Damage and the Trace-Gas Index Issue," by John M. Reilly; Part 3—Agriculture, Natural Resources and Global Change: 6. "Agronomic and Economic Impacts of Gradual Global Warming: A Preliminary Analysis of Midwestern Crop Farming," by Harry M. Kaiser, Susan J. Riha, David G. Rossiter, and Daniel S. Wilks 7. "A Sensitivity Analysis of the Implications of Climate Change for World Agriculture," by Sally M. Kane, John M. Reilly, and James Tobey; 8. "Government Farm Programs and Climate Change: A First Look," by Jan Lewandrowski and Richard Brazee; 9. "Modeling Western Irrigated Agriculture and Water Policy: Climate-Change Considerations," by Noel R. Gollehon, Michael R. Moore, Marcel Aillery, Mark Kramer, and Glen Schaible; 10. "Methodology for Assessing Regional Economic Impacts of and Responses to Climate Change: The MINK Study," by William E. Easterling, Pierre R. Crosson, Norman J. Rosenberg, Mary S. McKenney, and Kenneth D. Frederick; 11. "Inbedding Dynamic Responses with Imperfect Information into Static Portraits of the Regional Impact of Climate Change," by Gary W. Yohe; 12. "Biological Emissions and North-South Politics," by Thomas Drennen and Duane Chapman; Part 4—Forestry and Global Change: 13. "Global Change and Forest Resources: Modeling Multiple Forest Resources and Human Interactions," by Michael A. Fosberg, Linda A. Joyce, and Richard A. Birdsey; 14. "Climate Change and Forestry in the U.S. Midwest," by Michael D. Bowes and Roger A. Sedjo; 15. "The Role of Agriculture in Climate Change: A Preliminary Evaluation of Emission-Control Strategies," by Richard M. Adams, Ching-Cheng Chang, Bruce A. McCarl, and John M. Callaway; 16. "Policy and Research Implications of Recent Carbon-Sequestering Analysis," by Kenneth R. Richards; Part 5—International Perspectives of Global Change: 17. "The Enhanced Greenhouse Effect and Australian Agriculture," by David Godden and Philip D. Adams," 18. "Global Warming and Mexican Agriculture: Some Preliminary Results," by Diana M. Liverman; 19. "The Impact of Expected Climate Changes on Crop Yields: Estimates for Europe, the USSR, and North America Based on Paleonanalogue Scenarios," by Gennady V. Menzhulin; 20. "Perspectives on Potential Agricultural and Resource Effects of Climate Change in Japan," by Ryohei Kada; Part 6—Review Chapters: 21. "Global Climate Change: Effects on Agriculture," by Timothy Mount; 22. "Evaluating Socioeconomic Assessments of the Effect of Climate Change on Agriculture," by Steven T. Sonka; 23. "Implications of Global-Change Uncertainties: Agricultural and Natural Resource Policies," by W. Kip Viscusi; Part 7—Data and Research Priorities: 24. "Data Centers and Data Needs: Summary of a Panel Discussion," by Timothy Mount; 25. "Setting Priorities for Global-Change Research in Agriculture," by John M. Antle; 26. "Research Priorities Related to the Economics of Global Warming," by Michael Potier and Tom Jones.

Comparing U.S. and EC Dairy Policies

Political Economic Analysis of U.S. Dairy Policies and European Community Dairy Policy Comparisons. *By Mary A. Marchant. New York: Garland Publishing Co., 1993, 273 pages.*

Reviewed by Larry Salathe

This book compares the dairy policies and the performance of the dairy sectors in the United States and the European Community (EC) and presents theoretical and empirical models to explain changes in the U.S. support price for manufacturing milk. The book also graphically depicts the effects of various policy instruments on domestic production, consumption, prices, and the international market for dairy products, reviews past studies that examine the effects of the U.S. milk price support and federal order programs, and contains a very thorough bibliography (in excess of 50 pages).

The book begins by providing a historical review of the dairy policies and trends in production, consumption, prices, surpluses, and government dairy program costs in the United States and the EC. The author discusses the history of federal milk marketing orders and the dairy price support program in the United States and the EC's Common Agricultural Policy (CAP). Economic models are presented to graphically illustrate the domestic and international effects of these policies. Despite the complexities of the U.S. and EC dairy programs, this material is very readable.

Unfortunately, the discussion of dairy policies and trends ends in the mid-1980's. In the mid-1980's, U.S. dairy program costs averaged about $2 billion per year and the federal government was purchasing large amounts of butter, cheese, and nonfat dry milk. Since the mid-1980's, reductions in the support price, marketing assessments, and the dairy termination program have greatly reduced government surpluses and the cost of the diary program. In FY 1992, U.S. dairy program costs amounted to $232 million and butter was the only dairy product in which the government held significant surpluses.

The succeeding chapter reviews theoretical and empirical models that endogenize government behavior. The motivation for reviewing this literature is to develop a model that can be used to predict the level of the support price for manufacturing milk. The author provides a more than adequate literature survey, which suggests two possible approaches for endogenizing government behavior. The first approach is to estimate an econometric equation that relates the policy instrument to a variety of variables that may influence the policy outcome. These variables could include noneconomic variables, such as political contributions by special interest groups. The second approach assumes policymakers set policy instruments to maximize a social welfare function, which equals the weighted summation of producer surplus, consumer surplus, and taxpayer cost. Solving the first order conditions yields a system of equations that may under certain conditions be solved for the implied weights that policymakers attach to consumers, producers, and taxpayers and relates the level of a policy instrument to sector variables. The author discusses each approach in detail and demonstrates how the use of a social welfare function can be used to derive the implied weights policymakers attach to various groups.

The final chapter of the book presents an econometric model of the U.S. dairy industry. The model includes econometric equations to estimate the supply and demand and support price for manufacturing milk. The support price for manufacturing milk was found be positively related to the support price lagged and negatively related to the level of government stocks of dairy products, total farm income lagged, and the federal budget deficit. An alternative specification indicated the support price was positively related to the support price lagged and negatively related to the federal budget deficit, the ratio of dairy program costs to the total cost of farm programs, and the difference between the U.S. support price and the world price for manufacturing milk.

The coefficient of the lagged support price was significantly above 1 in each econometric equation presented by the author, which leads to the conclusion that the support price will increase significantly from year-to-year even though all variables remain constant. This result appears to be in conflict with the more than 30 percent decline in the support price since 1981. Over the past several years, reducing the federal budget deficit and the cost of the dairy and other farm programs were the primary motivating factors for lowering the support price. That was not the case prior to the early 1980's when parity was used to establish the support price for manufacturing milk.

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Maximization of the social welfare function leads the author to conclude that the support price is determined by the net change in government stocks of dairy products. However, the reported econometric equations indicate that a significant negative relationship does not exist between the support price and government stocks. In addition, this approach leads to the conclusion that policy-makers place a negative weight on producer surplus and on consumer surplus. This result is inconsistent with traditional welfare analysis, which places positive weights on producers, consumers, and taxpayers.

This very readable book provides a good reference for those interested in models of the dairy industry and models that endogenize government behavior. It also contains an indepth description of the origin and evolution of dairy policy in the United States and the EC up until the mid-1980's. The graphical analysis of dairy programs is extremely helpful in demonstrating and explaining the economic consequences of the U.S. and EC dairy programs.

Understanding Informational Regulation

Informational Approaches to Regulation. *By Wesley A. Magat and W. Kip Viscusi. Cambridge, MA: MIT Press, 1992, 274 pages, $32.50.*

Reviewed by Jean C. Buzby

The U.S. Government's increasing involvement with informational provision programs is geared toward helping consumers make decisions on risky products and activities. Some of these programs have successfully helped reduce consumption of risky products (e.g., saccharin-based drinks, tobacco) while others have had little impact in modifying economic behavior (e.g., mandatory seatbelt campaigns). Wide variations in program effectiveness raise questions about risk communication and invite new design strategies for informational programs. The new food labels, mandatory after May 8, 1994, are the latest informational programs relating to agriculture.

Accurately expressing risk in informational programs is difficult and may be the largest hurdle to successful implementation. Risk-based literature in disciplines such as decision sciences, economics, marketing, and psychology recognize that consumers have trouble understanding risk concepts and incorporating risk into decisionmaking. Magat and Viscusi chisel away at the unknowns surrounding risk by setting up experiments that control the amount and type of risk information conveyed in different formats. They uncover striking variation in consumer behavior in response to different risk information and make inroads in understanding how risk communication, altruism, and demographic variables help explain this variability. Most importantly, the findings provide a valuable foundation for effectively communicating risk and other information, and will facilitate future work on modeling consumer behavior. This book is the 19th in the Regulation of Economic Activity series.

Private sector and government readers involved in designing, implementing, and evaluating informational labels will benefit most from the book. Survey practitioners who implement risk-based or information-based surveys will benefit from the detailed descriptions of the survey methods and from the sample surveys provided in the Appendixes. The book's extensive survey details document their findings in a compelling manner. However, lay readers may prefer to skip the technical sections to find the nuggets of insight on consumer decision making and risk perception.

Focusing on hazard warnings (labeling for carcinogens in California food, home chemical use of a toilet bowl cleaner and pesticide) and benefit-cost reports (home energy efficiency ratings), three case studies depict how consumers respond to risk and other information. The hazard warning studies observed how different individuals notice, recall, and intend to act upon hazard warnings. The home energy efficiency study flooded participants with benefit and cost information on items such as insulation, attic ventilation, and replacement furnaces to analyze responses from complicated nonrisk decisions.

The first study showed participants hazard-warnings labels for either a toilet bowl cleaner or an outdoor insect spray to determine how different labels affect precautionary behavior and consumers' valuations for injuries that would be prevented. The labeled chemical containers were similar to their commercially available counterparts. Some labels used the Environmental Protection Agency's (EPA) current hazard warnings while others reflected a series of incremental redesign changes. Participants were asked to read the labels and then answer questions on demographics, purchasing intentions, and their willingness to pay for a safer product.

One portion of the survey focused on the consumers' valuation of reducing acute morbidity losses from four minor hazards; child poisoning, eyeburns, inhalation, and skin poisoning. Each participant was given a description of two of the four hazards, depending on which chemical they had been given and whether they had children under the age of five. The mean value placed on a statistical injury reduction from the insecticide ranged from $1,233 to $2,860 while the value for the toilet bowl cleaner ranged from $612 to $1,010. For both products, participants valued child poisoning injuries higher than the adult injuries (i.e., parental altruism).

Magat and Viscusi addressed the issue of private valuation of risk versus social valuation of risk. Altruism to other members of the same state was greater than private risk valuations and altruism to out-of-state people. The authors speculate that this limit on altruism may reflect closer familial ties within a state and a willingness to pay for

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altruism that diminishes with the level of total risk reduction expenditures.

Magat and Viscusi found that consumers have a positive yet diminishing valuation for increasing levels of risk reduction with the exception of the point where the risk is completely eliminated (i.e., zero risk). For the complete elimination of risks, people will pay extremely large "certainty" premiums relative to the premiums they would pay for other risk reductions of equal magnitude. Consumers have a better understanding of the meaning of "zero risk" than other risk levels and this certainty reduces anxiety and other decision-making costs.

Respondents were asked to value risk increases and decreases. Many would not accept any risk increase, even if the product was discounted. The authors suggest, consumers may perceive risk increases and decreases of comparable magnitudes differently.

Magat and Viscusi use a memory recall technique that prompts participants to mention everything they can remember about the label (i.e., open-ended). While difficult to code and interpret, the authors feel the insights gleaned are superior. They found this technique assesses the label information absorbed by the participant and determines the prominence, ordering, and linkages of this information in the participant's memory. Assumptions are that greater recall about the products' risk and the "do's" and "don'ts" when handling the product leads to greater precautionary behavior and that participants do not follow all the averting behavior they remember. Magat and Viscusi use the memory recall technique as a refined experiment to test the impact of "information overload" which is a phenomena where too much information reduces the amount that people remember. Results revealed that although hazard warnings substantially affect precautionary intentions, too much information decreased the effectiveness of hazard-warnings.

The other hazard warning study examined the labeling requirements of carcinogenic food products mandated by California's Proposition 65. The objectives were to observe how the warnings affected consumers' willingness to pay for the product and to determine how accurately the risk information was expressed to consumers. Consumers' interpretations of the risks tended to overstate actual risks.

The energy audit study provided consumers with cost and benefit information about available energy conservation investments for their homes and evaluated whether consumers made better energy choices. The authors consider budget constraints because some renters and low-income homeowners did not have a sufficient cash flow to make energy saving investments. Again, the structure and format of the information influenced the program's effectiveness.

The book concludes with guidelines for selecting among the different types of informational provision instruments (e.g., warning labels, benefit-cost reports) for the greatest impact on consumer response. Magat and Viscusi's belief that careful design and implementation are essential for success is displayed by their attention to specific nuances such as the arrangement of information and print size on the labels. Designing and implementing a successful informational program is not a trivial endeavor and they warn against simply using a successful program as a model for all circumstances.

Magat and Viscusi also establish guidelines for evaluating informational regulations. The guidelines incorporate consumers' limitations about risk processing and quantity of information that they can absorb.

Informational Approaches to Regulation provides a synthesis of existing literature on informational regulations while making several important contributions to the design and evaluation of such regulations. Providing this strong foundation invites future work on modeling consumer behavior. I recommend the book to those working in the area of informational regulations and to those curious about consumers' reactions to risk.

The book features: **Hazardous Chemical Product Labeling: Methodology**—"Methodology for the Consumer Surveys," **Hazardous Chemical Product Labeling: Risk Valuation**—"Risk Valuations and the Rationality of Consumer Behavior" with Joel Huber, "Altrustic and Private Components of Risk Valuation" with Anne Forrest, **Hazardous Chemical Product Labeling: Cognitive Processes and Behavior**—"Consumer Responses to Risk Information" with Joel Huber, "Effects of the Format of Labels on Consumer Responses to Labels" with Joel Huber, "The Correspondence between Actual and Experimental Behavior," **Two Studies of Other Applications of Informational Regulation**—"Home Energy Audits" with Peter F. Brucato, Jr., and John W. Payne, "Predicting the Effects of Food Cancer Risk Warnings on Consumers," "Implications for Information Provision Policies." Twelve appendixes supply added information and examples of the surveys.

A Useful Study of Commodity Promotion

Commodity Advertising: The Economics and Measurement of Generic Programs. *By Olan D. Forker and Ronald W. Ward. New York: Lexington Books (Macmillan), 1993, 294 pages, $21.95.*

Reviewed by Karen Ackerman

This book is the first comprehensive study of generic advertising and promotion by agricultural commodity organizations. The authors, Professors Olan Forker and Ron Ward, present both the economic and institutional aspects of commodity promotion, drawing on several disciplines for their analysis. Overall, the authors present a very complex subject in a straightforward manner.

As early as the 1880's, U.S. agricultural producers joined together to fund and conduct activities to stabilize prices and improve their returns. In the century that followed, a complex web of state and federal regulations established a plethora of producer organizations with authority to conduct many types of promotion, research, and marketing activities. In the mid-1950's, many commodity organizations expanded their traditional activities by cultivating partnerships with the federal government to develop export markets for U.S. products.

Higher funding and greater scrutiny have increased both the importance of commodity promotion as a marketing tool and the need to evaluate its performance. Commodity organizations currently manage extensive research and promotion programs which include activities that emphasize product as well as market development. Funding from producers has increased due to the expansion of check-off programs. Federal funding for export market promotion grew substantially since the mid-1980's, peaking in 1992, before falling due to budgetary pressures.

The book is divided into 8 chapters. In the first chapter, the authors introduce their subject, position it in the spectrum of food marketing issues, and develop a justification for producers' support for generic advertising. The authors propose a theory of commodity advertising in the second chapter which provides the theoretical underpinning for their discussion of evaluation. The third chapter examines promotion objectives and strategies. Legislative, producer, and administrative support for commodity advertising is discussed in the fourth chapter. Chapter 5 describes the current promotion organizations and activities. After presenting different types of program evaluations in Chapter 6 and case studies of evaluations in Chapter 7, the authors conclude the book with evolving policy challenges.

The authors propose a solid, workable framework for econometric analysis of commodity advertising. They define commodity advertising as a means of informing consumers about product characteristics. Generic advertising adds value to the original product by informing consumers about product attributes that they might not have known previously. Thus, generic advertising expenditures become an argument of consumer demand and can be considered in a demand equation with other variables such as price and income.

Defining commodity advertising as a means of conveying information to consumers is one approach to the analysis of commodity promotion. However, some generic advertising appeals more to consumers' emotions than it conveys information. Analyzing advertising as a means of altering consumer behavior has proven to be less operational in econometric frameworks. Meanwhile, consumer research has become more sophisticated and more centered in psychological models of consumer behavior.

The authors are most successful when they draw on their considerable experience to develop guidelines for promotion program operation and evaluation. In Chapter 2, the authors list the factors which affect the success of commodity advertising. For example, the authors indicate that it is easier to communicate information about characteristics of products that do not lose their identity in the marketing channels. In Chapter 3, the authors present several objectives of commodity promotion and use basic economic theory to illustrate how objectives are met.

In Chapter 6, the authors present several evaluation approaches and methodologies and discuss their appropriateness. The authors emphasize that the approaches and methods chosen for program evaluation must reflect the chosen program criteria. If program managers are asked to address returns to producers, an econometric approach may be required. If the criterion to be addressed is improved consumer awareness, program managers should conduct a comparison of consumer aware-

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ness surveys before and after the marketing campaign. This chapter also will be useful for advertising agency managers handling commodity promotion accounts.

The authors also draw distinctions between program objectives and performance criteria, preprogram and post-program evaluation efforts, controlled samples or market tests, and studies of consumer behavior. They develop theories defining anticipated promotion effects. For example, the authors propose that the rate of response to promotional efforts depends on the product and level of market maturity. The introduction of a product with highly "publishable attributes" may produce a fast (and possibly large) response. Products that already are familiar to consumers may require more promotion investment to achieve small responses. Promotion efforts are not useful at all when consumption is high and consumers are highly familiar with the product's characteristics.

The book is aimed at a wide range of prospective readers, including commodity promotion board members, university students, economic and consumer researchers, government policymakers, and commodity organization promotion managers. The second, third, sixth, and seventh chapters could be extracted for a course on econometric analysis of commodity promotion. Potential commodity organization board members will benefit from the discussion of promotion objectives in the third chapter, the development of the institutions, and the strategies adopted by a range of agricultural commodity organizations.

The book generally was easy to read. However, I had to hack through the forest of definitions in Chapter 1. I would suggest that less academically-inclined readers skip much of Chapter 1.

While this book is an exhaustive study of commodity promotion in the United States, it does leave a few areas for further research. Some open issues include: the effectiveness of export versus domestic promotion, the relationships between commodity promotion and domestic price support programs, the cross-commodity effects of commodity promotion, the ever-popular concerns about data, and potential improvements in evaluation approaches.

In the 1990's, funding from national check-offs increased by about $80-90 million annually, but Federal funding for export promotion dropped to about $130 million annually in 1994 from $230 million annually from 1989 through 1992.[1] As Federal funding for export promotion is reduced, export promotional efforts will compete with domestic advertising for producer funds. Producers will seek comparisons between returns on domestic and export promotions as guidance for funding allocations. The authors did not advertise their book as a guide to the analysis of export promotion, although the conceptual framework presented in this book may provide a basis for analysis of the effects of non-price promotion on export demand. However, the application of the framework presented in this book to the evaluation of export promotion requires further attention from researchers.

Generic advertising and promotion covers a wide range of agricultural commodities, but funding levels represent a small share of U.S. Department of Agriculture support for primary commodities such as grains, oilseeds, and cotton. An increasingly market-oriented approach to farm legislation should motivate researchers to analyze the costs and benefits of commodity advertising versus price support programs.

The bulk of the demand (and the funding) for evaluation of commodity promotion has come from the commodity organizations themselves. Many of the questions answered by the analyses address the needs of commodity program managers. However, researchers might want to apply their skills to larger policy questions such as the cross-commodity effects of generic promotions and the costs and benefits of generic promotion versus government and marketing order price supports.

Finally, the authors thoroughly discuss the importance of continuing to develop appropriate data for analyses and new analytical approaches and methodologies. Professors Forker and Ward have given us an admirable examination of generic commodity evaluation. Their book is a good foundation for others to build upon.

[1]About 60 percent of Federal agricultural non-price promotion programs fund generic export promotions. The rest of the Federal non-price export promotion program funds are used to reimburse up to one-half of the eligible advertising costs of participating private companies in selected export markets.

ERRATUM

Alternative Forms for Production Functions of Irrigated Crops: Correction

Michael R. Moore, Noel R. Gollehon, and Donald H. Negri

Two regrettable typographical errors appeared in our recent paper published in the Volume 44, Number 3, issue of this journal.

(1) On page 19, several elements of Table 1 are described incorrectly. A correct version of Table 1 is printed below:

Table 1—Characteristics of crop-specific variables[1]

Crop	Unit	Irrigated crop yield		Irrigation water-application-rate[2]		Irrigated acres		Percentage of observations by irrigation technology[3]	
								Gravity	Sprinkler
		Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	--------Percent-------	
Alfalfa	tons	4.33	2.05	29.1	19.5	263	560	59.7	39.6
Barley	bu.	79.5	26.5	20.7	14.5	253	515	51.3	47.7
Corn silage	tons	20.40	5.69	24.0	14.3	158	291	70.0	29.7
Cotton	lbs.	916	371	32.5	20.5	936	2,727	86.5	12.8
Dry beans	cwt.	20.43	6.03	22.6	13.6	200	286	57.9	41.9
Grain corn	bu.	132.1	31.9	22.1	13.3	606	1,085	53.9	45.6
Grain sorghum	bu.	86.0	27.3	16.9	10.0	328	397	71.9	27.6
Other hay	tons	2.14	1.21	22.9	16.7	594	1,381	78.5	19.4
Potatoes	cwt.	348	121	28.2	16.1	447	707	18.3	80.4
Rice	cwt.	67.8	13.0	62.5	21.2	856	1,033	100.0	0.0
Soybeans	bu.	37.9	10.9	12.1	8.1	196	226	50.5	49.5
Sugar beets	tons	23.4	5.7	32.9	16.6	319	386	74.7	25.3
Wheat	bu.	73.6	26.9	19.1	13.2	441	921	53.4	46.6

[1]Space limitations do not permit listing of the statistical characteristics or percentages of remaining variables used in the analysis. They are available from the authors.
[2]Irrigation water application rate measured as acre-inches per acre.
[3]The percentage of observations in other irrigation technologies is the difference between 100 percent and the percentages in gravity and sprinkler technologies.

(2) On page 23, the column headings for the continuation of Table 2 are incorrect. The correct version of the page 23 portion of Table 2 is:

Table 2—Crop-water production function estimates, Cobb-Douglas specification (continued)

Independent variable	Irrigated crop			
	Rice	Soybeans	Sugar beets	Wheat
	Cwt	*Bu.*	*Tons*	*Bu.*
Adjusted R^2	0.539	0.096	0.369	0.373
No. observations	142	333	288	1,923

[1]Numbers in parentheses are t-statistics.
[2]As described in the text, coefficients on the land variable measure returns to scale because the production functions are on a per-acre basis.
[3]d.v. = dummy variable.
[4]NA = insufficient observations available to estimate the variable.

References

Moore, Michael R., Noel R. Gollehon, and Donald H. Negri. 1993. "Alternative Forms for Production Functions of Irrigated Crops," *The Journal of Agricultural Economics Research*. Vol. 44, No. 3, pp. 16-32.

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